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**Wool and Wool-Based Textiles in the West European Economy, c.800 - 1500:
Innovations and Traditions in Textile Products, Technology, and Industrial Organisation**

by

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The full bibliography and a set of statistical tables will be found appended to the companion paper, **The West European Woollen Industries and their Struggles for International Markets, c.1000 - 1500** [<http://www.economics.utoronto.ca/ecipa/archive/UT-ECIPA-MUNRO-00-04.html>]. As noted in the title- page for that paper, the prospective publisher of both of these papers has forbidden the use of traditional footnotes, restricting references to in-text citations.

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Wool and Wool-Based Textiles in the West European Economy, c.800 - 1500: Innovations and Traditions in Textile Products, Technology, and Industrial Organisation

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Abstract:

This paper is a necessary companion to the one entitled *The West European Woollen Industries and their Struggles for International Markets, c.1000 - 1500*. No one can properly comprehend that five-century history of international competition for textile markets, without some basic understanding of the products that the manufacturers sought to sell in seeking customers in those markets, and some understanding of the changes in industrial organisation that enabled producers to market their products.

During these five centuries, West European textile producers marketed a very wide range of wool-based textiles, classed under the general headings of woollens, worsteds, and semi-worsted 'stuffs'. They ranged in quality and price from relatively cheap – those that a master craftsmen could buy with two week's wages – to the ultra-luxurious woollen *scarlets*, aimed at aristocratic markets: extremely costly fabrics, rivalling the best silks, whose purchase might cost a master mason several years's wages. Wools, of course, constituted the essential ingredient of all these fabrics, and certainly for luxury quality woollens, the most expensive input, accounting for 60% - 75% of the cost of production, with other raw materials (oils, fullers' earth, teasels, and dyestuffs, etc.) accounted for another 10%. To understand both the supply and demand factors involved in marketing these textiles, the historian must clearly explain the economics of wool production and of supplying other raw materials; and then the techniques involved in the manufacturing processes: wool-sorting and preparation, combing, carding, spinning, weaving, and (for woollens), fulling and felting, teasing or napping, shearing, dyeing, and other finishing processes. The historian must then demonstrate how the wools, dyestuffs, and manufacturing processes differed between and amongst the various types of woollens, worsteds, and semi-worsted stuffs. To understand the marketing of these textiles, the historian must also delineate the nature of product innovations (styles, colours, etc.) and then relate the *relative* prices for these textiles to (1) the cost of a basket of essential consumable goods, and (2) the daily wage-earnings of master craftsmen.

Underlying all these complex analyses lies a more fundamental question: a demonstration of Adam Smith's famous dictum 'That the Division of Labour is Limited by the Extent of the Market'. This paper attempts to show how the expansion of international market networks from the 10th century transformed an essentially rural domestic handicraft industry into a very complex, essentially-urban based industry, with a very complex division of labour; and how market forces and supply factors brought about a veritable 'industrial revolution' in these textiles – in weaving, carding, spinning, and fulling particularly – that, relative to the conditions of the medieval economy, were as important as the 18th-century Industrial Revolution in cotton textiles. Somewhat surprisingly, this wool-based 'industrial revolution' was more or less complete by the 15th century, thus leaving a technological hiatus until the 18th century.

The companion paper seeks to demonstrate, in terms of supply and demand models (but principally a transaction cost model), how structural changes in the late-medieval economy centuries forced so many textile-producers to forsake the export-oriented production of cheaper, lighter textiles to concentrate upon the far higher-produced, much more luxurious heavy-weight woollens (whose durability would last several lifetimes). The relevance of those market changes for technological change becomes clear when an examination of the new industrial processes reveal that many of them, while cutting production costs, so impaired quality that producers, competing in luxury markets, eschewed them for fear of losing customers. The paper shows how urban guilds and governments imposed quality-controls, in acting as agents for draperies engaged in monopolistic-competition, accepting some positive innovations, while rejecting others. In contrast, the essence of the modern Industrial Revolution in textiles was in vastly improving quality, while also cutting costs.

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Wool and Wool-Based Textiles in the West European Economy, c.800 - 1500: Innovations and Traditions in Textile Products, Technology, and Industrial Organisation

John H. Munro (University of Toronto)

I: WOOL-BASED TEXTILES IN THE ECONOMY OF MEDIEVAL EUROPE

No form of manufacturing had a greater impact upon the economy and society of medieval Europe than did those industries producing cloths from various kinds of wool: those now commonly known as woollens, worsteds, and hybrid 'stuffs'. For agriculture, then the overwhelmingly dominant sector, these industries collectively provided a very major source of aggregate demand: for wools, dyestuffs, butter or oil, fuller's earth, teasels, and indeed also for much of its rural work-force. For the industrial sector itself, both rural and urban, they constituted the single most important form of manufacturing, measured by total employment and value of output, in so many scattered regions of medieval Europe. Similarly, as Eleanora Carus-Wilson (1952) has observed for the commercial sector, wool-based textiles, 'being neither fragile nor perishable', with a high value:weight ratio, constituted the leading manufactured commodity entering into both regional and international trade, supplying not just European but also West Asian and North African markets. Of almost equal importance was the international trade in the essential raw materials: in wools, dyestuffs, and alum. Finally the international trade in both raw materials and finished textiles also played a major role in developing the financial sector, in bills obligatory, bills of exchange, and other credit instruments, all so vitally important in funding and effecting these commercial transactions. For all these reasons, therefore, the wool-based cloth industries provided an important foundation for medieval urbanization, especially in western Europe; and although the countryside gained a relatively greater industrial importance during the later medieval and early-modern eras, those rural producers who served international markets were never able to function independently of the still powerful urban economies.

In meeting one of the most basic of all human needs, textile manufacturing was of course almost universal across medieval Europe; and the majority of textiles, apart from those 'homespun' fabrics consumed directly by their producers and families, were sold or exchanged locally. But the ability to produce textiles

better than mere homespun, and especially those that would satisfy the more refined demands for comfort, warmth, durability, and style, in both dress and household furnishings, was much more regional in scope. As textile production became more and more oriented towards fully monetized markets and more dependent on long-distance trade for raw materials as well as for consumers, regional specialization in the various textile industries became much more pronounced.

To some extent, though less than one might suppose, some new cloth-producing regions in medieval Europe achieved their success through product specialization, particularly in acquiring a comparative advantage in raw material, labour, organizational, or transport and marketing costs, even if such advantages were gained through various injuries that had been inflicted upon older producers. To a much greater extent, however, the general diffusion of commercial, export-oriented cloth manufacturing resulted from a complex interplay of forces in the international competition for markets, as new entrants were attracted by the profits or 'economic rents' that the earlier leaders had once enjoyed, perhaps only too briefly. Such competition, particularly in cheaper, less differentiated cloths, was bound to eliminate such 'rents' in the higher-cost or less advantageously situated cloth-producing regions, forcing many out of production. For, by the later Middle Ages, only limited cost savings could be achieved from technological or organizational changes, or from new sources of raw materials. Consequently, the critical cost changes that determined exit from or entry into the cloth industry -- regional growth or decline -- were chiefly those involving transportation, marketing, and other transaction costs in both raw materials and the manufactured cloths. Paradoxically, therefore, the development of some new textile producers in later medieval Europe, particularly in Mediterranean and Central Europe, reflects not so much regional specialization and 'economic growth' as an opposite trend towards 'import substitution' and regional self-sufficiency, when rising transaction costs eliminated many foreign cloths from markets formerly supplied by far-distant northern producers.

The history of both the medieval and early-modern European cloth industries has to be understood first in terms of the widely diverse various fabrics manufactured and secondly in terms of the various types

of wools from which they were produced. These textiles, differing so markedly in texture, weight, fineness, quality, and price, formed a seamless continuum that ran from the very cheap and coarse to the very fine and extremely costly, exceeded in aristocratic quality and price only by the better Oriental and Italian silks.

Woollens, worsteds, and serges in the history of English textiles

For historians of the English cloth industry at the dawn of the modern era, however, cloth manufacturing presented not a seamless web but a sharp dichotomy between its two main branches, at polar ends of the quality continuum: the woollen and the worsted industries. Much too conveniently they have been called, respectively, the Old and the New Draperies. But on closer historical inspection, many of the so-called New Draperies of Elizabethan England produced a wide range of worsted and hybrid worsted-woollen fabrics; and collectively they were not so new after all, but rather a resurrection of a far older medieval industry, some of whose hybrids products were commonly called *serges*, though that term was often also used as a synonym for worsted. The term worsted, it must be noted, is peculiarly English, and is related to the Norfolk village of Worstead, the reputed centre of the earlier, medieval industry.

Nevertheless, the distinctions between worsteds and woollens, as ideal or ‘model’ types, remain fundamental in the history of European textile manufacturing, in so far as they are based upon the wool properties peculiar to each type of cloth. Whether or not these differences between woollens and worsteds were so clearly distinct in the medieval era as they became during the early-modern era remains to be seen. According to traditional views of this ‘ideal’ dichotomy, medieval woollens were the denser, heavier, and usually more expensive cloths, composed of costly, fine, short-stapled, curly, scaly-fibred wools, which supposedly were prepared by carding, with wired brush-like tools (discussed below on pp.). The carded wools were then spun on the hand-powered spinning wheel, generally the so-called ‘Great Wheel’, to produce the yarns that were then woven on the horizontal loom; and, in traditional English historiography, almost all writers have asserted or assumed that both the warp and weft yarns were spun in this fashion. Weaving, however, did not complete the basic manufacturing stage, because the woven fabrics, when taken

down from the loom, lacked sufficient strength to prevent tearing. Thus to give these fabrics the requisite durability, and also the weight and cohesive texture for which medieval woollens became so famous, they had to undergo the process known as fulling: involving a combination of pressure, heat, water, and chemicals to force the scaly wool fibres to shrink and intermesh, forming a very densely felted, strong and virtually indestructible fabric. The fulled cloth, after being hung to dry on a tentering frame and then stretched, to remove wrinkles, was then subjected to the finishing processes of napping (dressing, raising, or teaselling, with teasels) and shearing, in an alternating series, to bring up and cut off all the protruding loose fibres. These finishing processes of felting, napping, and shearing thus effectively obliterated almost all trace of weave, except for those 'striped' woollens in which the warp and weft yarns were dyed with different colours, and for some woollens in which one side was more thoroughly felted than the other.

The worsted cloths of this classic, theoretical dichotomy were, in very sharp contrast, light, and quite cheap fabrics, composed, in both warps and wefts, of combed wools that were coarse, straight, and long-fibred. In the earlier medieval era, they had been spun with the traditional drop-spindle and distaff, commonly known as the 'rock'. If the initial versions of the spinning wheel, introduced from the late thirteenth century, did not prove to be fully satisfactory in using these straight-fibred combed wools, a subsequent improvement, known as the Saxony Wheel, with an additional 'flyer' bobbin, did come to be the preferred method of producing worsted yarns (see pp. 000 below). The yarns, spun by either the 'rock' or the 'wheel', were so strong and tightly twisted that manufacturing was virtually complete with the weaving process, except for bleaching or dyeing and pressing. Thus the classic true worsteds underwent no fulling, napping/teaselling, or shearing; and indeed their coarse, much straighter wool fibres lacked the felting properties required for these finishing processes. The distinguishing visible feature of these model worsteds, therefore, was their highly visible weave, of various designs, chiefly twilled, designs that normally could not be seen in a true woollen.

The draperies ointes and draperies sèches in the history of continental textiles

The foregoing dichotomy between woollens and worsteds, to be examined more critically in the sections on technology below, is much less familiar to historians of the continental textile industries, many of whom associate carding in particular not so much with fine woollens as with many coarser, cheaper fabrics. The chief distinction of continental historians, and their own peculiar dichotomy, lies in the contrast between the so-called ‘greased’ and ‘dry’ draperies: i.e. *draperies ointes* and *draperies sèches*; or in Flemish (Dutch) the *gesmoutte draperie* (*lakenindustrie*) and *droge draperie*. In France and the Low Countries, these ‘dry’ draperies were also commonly called ‘light draperies’: *draperies légères*, or *lichte draperie*, and of these latter industries, the most prominent in both medieval and early-modern Europe were the *sayetteries*. However, many *draperies légères*, including many though not all *sayetteries*, produced hybrid fabrics, often called *serges* as well as *sayes* (says), which were composed of dry, long-stapled worsted warps, and greased, short-stapled woollen wefts. Thus once again the fundamental distinction between the two main industrial branches and their hybrid offspring is to be found in the wools and their processing.

Medieval Wool Preparations for the *draperies ointes* and *draperies sèches*

Indeed, all cloth-making necessarily began with wool-sorting, because any particular shorn fleece or woolfell (the hide of a slaughtered sheep) contained wools of varying degrees of staple-length and fineness, depending upon the nature of the fleece or woolfell. The wool-sorter segregated and reserved the finer, shorter-stapled wools for woollen-cloth production, i.e. for the *draperie ointe*. The very shortest were used to spin the weft yarns; those of medium length, for the warps; and those that were truly long and coarse were reserved for the *draperies sèches*, or for the warps in other, serge-type *draperies légères*. The wools were then cleansed; but those destined for the *draperie ointe* were the most rigorously scoured, with hot alkaline water, lye, and stale urine, to remove the natural lanolin and other natural greases, dirt, and other foreign matter that constituted about 20 percent of the raw wools’ weight. After several rinsings, the wools were placed on wooden slats to dry in the sun, and were then beaten or ‘broken’ with sticks, often willow branches. Known in England as *willeying*, in France as *brisage de laines*, and in Flanders as *wullebreken*, this wool-

beating process removed any remaining foreign matter, separated the entangled or matted fibres, and completed the wool sorting.

The very fine, short-fibred, and curly wools for the *draperie ointe*, and for the wefts in some *draperies légères*, were then thoroughly re-greased and lubricated, with butter or olive oil, in order to replace the natural oils lost through such rigorous scouring; and such lubrication was vitally necessary to protect these fine, curly wools from any damage or entanglement in the ensuing production processes of combing, carding, spinning, warping, and weaving. That also explains another function of the fulling process: the removal of all this grease, along with the starchy warp-sizing, before it became rancid.

In the *draperies sèches*, their much coarser, longer, straight-fibred wools did not require such extensive greasing, though English evidence does indicate that such worsted-type wools did receive at least a very light oiling. As Chorley (1987) has rightly noted, these wools underwent very little or no scouring in their initial and cursory preparation, so that they retained sufficient natural lanolin. Furthermore, these much tougher wools were less likely to be damaged in the ensuing manufacturing processes. But if, as just indicated, the various products of the true *draperies sèches* did not require any fulling, the serge-type cloths produced in some of the *draperies légères* did require at least some cursory fulling, because of their greased, shorter-stapled wefts.

In summary, the English and continental wool-based dichotomies turn out to be essentially the same, at least for the later-medieval era, permitting us to equate the *draperies sèches* with the worsted industries, and the *draperies ointes* with true woollen manufacturing, while many of the *draperies légères* produced serge-like hybrid products. The virtual absence of the term ‘greased drapery’ in the English literature certainly does not mean that medieval English clothiers had ignored this crucial technique; for many documents specify that three pounds of grease were to be used for every ten pounds of wool (or one gallon of oil for every thirty-two pounds of wool). Unfortunately, however, we still lack sufficient knowledge about the technical properties of many wools used in medieval based textiles -- in particular the actual differences in their staple-

lengths and fineness – to classify them accurately according to these same categories, as woollens, worsteds, and serges.

II. THE MEDIEVAL WOOL SUPPLY

The supremacy of English wools

The only confident assertion to be made about medieval European wools is that some English varieties, though by no means all, were unrivalled for fineness, from the twelfth to sixteenth centuries. In 1282, an ordinance of the Bruges drapery, then exporting a wide variety of textiles, ranked its woollens in descending order of quality, specifying that those made from English wools were to be sealed with three crosses, those from Scottish wools with two crosses, those from Irish wools with one cross, and finally, those from the domestic Flemish wools, with a half-cross. In view of the later fame of Spanish merino wools in early-modern Europe, their absence from this list may seem surprising. But the Spanish wools of this era were quite different. Their use in any of the sealed cloths was strictly prohibited; and they were contemptuously classed along with *plootwollen*, *waterwollen*, *faulx lainages*, and waste-wools. In late twelfth- and thirteenth-century Bruges, such Spanish wools had been utilized in making cheap, coarse *saergen*; and in later thirteenth-century England they were evidently used for similar coarse, cheap, and light textiles, such as London *burels*, though the Andover weavers' guild (Hampshire) of this same era strictly banned them even for making cheap kerseys (*cersegis*). Whether the domestic Flemish wools were really inferior to the Irish is perhaps debatable; the Irish wools were evidently used chiefly for says and other serge or worsted-type cloths (i.e. *Iersche* wools, rather than *hierlandsche*, a Flemish term that term refers to domestic wools). For this latter type of cloth-making in the Low Countries, coarse Flemish, Scottish, Zealander, Frisian, Kempen, and Pomeranian, and some French wools (from Lorraine) came to be much more widely used. If some Scottish wools were or later became quite coarse, many were quite good enough, certainly in the thirteenth

and early fourteenth centuries, to make moderately fine quality woollens. Subsequently, however, in the later fourteenth and fifteenth centuries, the traditional woollen draperies in the Low Countries, and even some of the upstart *nouvelles draperies*, stipulated the exclusive use of English wools, as did the Florentine luxury woollen industry (up to the 1380s: see below, pp.).

Evidence from their drapery ordinances, from many price schedules of both English and continental provenance, and many literary sources show that throughout the High and Later Middle Ages only three English regions consistently produced the very high quality wools required for true luxury quality woollens. In descending order, they were: first, in the west, the Welsh Marches of Shropshire and Herefordshire (and the adjacent region of central-Wales, at least in the thirteenth century); second, the immediately contiguous Cotswolds districts of Worcestershire, Gloucestershire, and Oxfordshire (and, by the fifteenth century, also the adjacent regions of Berkshire); finally, in the east, and a rather distant third, Lincolnshire (the Lindsey, Kesteven, and Holland districts, in that order). Next in quality and price came various wools from other regions in the English Midlands. Amongst the lower quality but still ‘acceptable’ English wools, for medium grade woollens, were those from southern Yorkshire, East Anglia, and adjacent counties to the south, including some of London's ‘home counties’ (Essex, Kent, Sussex, Hampshire). Quite unacceptable, however, certainly by the later fourteenth and fifteenth centuries, were the far northern wools from Westmorland, Cumberland, Lancashire, Cheshire, Northumberland, Durham, and North Riding Yorkshire, and finally, those from Cornwall and Devon in the south-west, which were evidently the very worst of all. Indeed, Parliament subsequently agreed to exempt these inferior ‘slight’ wools (partially from 1379, fully in 1423) from the obligation to ship all wools destined for northern Europe to the crown-mandated Calais Staple (from 1363) because their values were too low to bear the export taxes and other ‘charges of the Staple’ (see below pp.).

Was this very wide range of English wool qualities, reflected in their prices, due principally to the genetics of sheep-breeding, to flock-management, or just to environment? Many agricultural historians doubt

that, in the medieval era, any distinguishable sheep breeds were to be found in England or indeed anywhere in continental Europe. Bowden (1962) has contended, with considerable authority, that these disparities were instead due almost entirely to the environmental factors of climate and nutrition. Somewhat paradoxically, the chillier the climate and the sparser the feeding, the finer would be the wool: or more precisely, the more likely, *ceteris paribus*, that a majority of wools in a given fleece would be fine and thin (25 - 30 microns), short-stapled (under 3 in. or 8 cm.), curly and scaly fibred. The sheep growing such fleeces, which weighed about 1.0 to 2.5 lb. (0.45 to 1.13 kg), were small but mature adults (usually female, i.e. ewes), perhaps even scrawny -- they certainly were not raised for their meat. The very hilly or mountainous terrain of the Welsh Marches, with rather poor pastures, would thus explain this region's supremacy in producing the very finest wools; and Eileen Power (1941) has recounted the pun of the famous English naturalist Sir Joseph Banks (1743-1820): that the Ryelands sheep of this region, especially from Leominster, 'deserved a niche in the temple of famine'. Lincolnshire, of course, was not blessed with similarly advantageous terrain; but Bowden explains the relatively good quality of its wools (especially the northern Lindsey) by the very scanty, inadequate pasturage available in this densely populated region of classic Open Field agriculture, so that landlords and peasants were forced to have their sheep graze on the sparse post-harvest stubble of the arable fields.

One may doubt, however, that the Bowden thesis explains everything to be known about the wools of the medieval British Isles, certainly not in this simplified form. Banks' pun to the contrary, neither extremely poor feeding nor very cold or hostile climates were really beneficial for wool qualities. Why indeed should wools from the far north of England and Scotland have been considered so very inferior in the later Middle Ages? On the other hand, if environment had been the chief determinant of wool quality, why were some thirteenth-century Cistercian abbeys able to sell Scottish wools at prices not much below those for good English wools? Furthermore, in this very same era, the Cistercians were also selling some wools from their eastern Welsh abbeys (Margam, Neath, Tintern) at prices above even those for the best Herefordshire wools,

while subsequently, in the later fourteenth and fifteenth centuries, Welsh wools came to be considered grossly inferior, and were thus virtually unexportable.

Undoubtedly, the resolution of this seeming paradox must be found in some combination of flock management and sheep breeding as equally critical determinants of wool qualities. The importance of breeding is certainly indicated by evidence that several thirteenth-century Cistercian abbeys had been importing expensive breeding rams from Herefordshire and Lindsey. By the mid-fourteenth century, if not even earlier, these Cistercian abbeys were no longer marketing wools, and had leased their pastoral lands to multitudes of small peasants, who raised their sheep in communal flocks and who lacked the capital, expertise, and scale-economies (for sheep segregation) to engage in effective breeding and to maintain flocks with high quality fleeces. Furthermore, the wool-price schedules from the thirteenth to the late fifteenth centuries indicate a continually widening gap over this period between the highest and lowest priced English wools, indicating that a much smaller proportion of the English wool supply came to enjoy proper flock management, or that a higher proportion of England's sheep came to be raised for meat rather than for fine wools.

There can be little doubt, from abundant evidence – supplied by the Franco-Flemish and Florentine draperies and by some scientific examination of wool particles – that the better grades of medieval English wools were indeed very fine and short-stapled, as just defined, for both warp and weft. References in some of the textile literature to fine woollens made from 'long-stapled' Cotswolds and Lincolnshire wools, as well as from short-stapled Ryelands, must be taken as historical anachronisms, reflecting conditions of a much later era; for the sheep from these regions did not become predominantly longer-stapled in their fleeces until the sixteenth or seventeenth centuries.

Indeed, Bowden carried his environmental theories even further to explain England's eventual loss of supremacy in producing fine wools, the consequent decline of her traditional woollens industry, and the 'rise of the New Draperies', from the about the mid-sixteenth century. In essence, he argued that the Tudor-

Stuart enclosures, more particularly those in the Midlands, ultimately if not immediately changed the character of English wools, to the severe detriment of the traditional woollens industry. For this thesis he cited not only zoological facts but also contemporary Tudor tracts to argue that the Enclosures of this era, by inducing a relative shift of sheep-raising to the more fertile Midlands plains, and especially by providing much richer pastures and year-around feeding, resulted in much larger, much meatier sheep, with far heavier, longer-stapled, and coarser fleeces: i.e. with wools that were far better suited to the worsted or semi-worsted fabrics of those famous ‘New Draperies’ that developed so rapidly and successfully from the early Elizabethan era (see below pp.).

While such a shift in the qualities of English wools undoubtedly did take place in this era, another explanation may lie in genetic factors: in selective breeding to produce much bigger sheep for the rapidly expanding urban meat markets. Such breeding, which inevitably did produce much longer and heavier fleeced-sheep, was much easier to pursue on enclosed, well-managed, highly capitalized estates than in peasant-directed agriculture, especially in the classic open-field regions of more communal agriculture (but also in the northern and western regions of supposedly non-communal agriculture).

The rise of Spanish merino wools

As the majority of English wools declined in quality during the Tudor-Stuart era, European supremacy in fine-wool production ultimately passed to Spain, with her growing flocks of merino sheep. But quite clearly these merino wools were in no way related to those despised Spanish wools of the twelfth and thirteenth centuries. Though many authorities have asserted that the merino wools date from those centuries, Lopez (1953) was undoubtedly correct in arguing the minority view that merino sheep were not introduced into Spain before the early to mid-fourteenth century. The name is probably derived from the North African Berber tribe, the Banu Marin, better known as the Marinids (or Merinids), who, in 1275, displaced the Almohads in Morocco and then invaded Spain, seeking to restore the former Almohad Empire (see below pp.). Possibly, during their temporary reconquests of Andalusia, the Marinids subsequently introduced some

Barbary sheep into Spain; in all likelihood, however, the Spanish themselves did so, though only after the final Castilian victory over the Marinid invaders at the Battle of Rio Salado in 1340, which brought relative peace to Christian Spain. Shortly thereafter, royal records indicate that Pedro IV of Aragon (1337-87) acquired some Barbary rams for his domains. The Spanish sheep that came to be known as merino were not only very different from the indigenous Spanish flocks, but evidently different also from the Barbary (North African) sheep, perhaps because of genetic interactions of recessive genes in the two breeds of sheep. The new, eventually very short-stapled merino wools (2 in. or 5 cm and under) may also have been produced by some special selective breeding, about which we really know nothing.

Possibly they were also the product of both flock management and various environmental factors. According to some historians, one such factor, again involving chilly climates and sparse feeding, that promoted improved fineness was *transhumance*: the annual migrations or itinerant pasturage, from the high northern plateaux of Leon and Segovia some 450 miles (725 km) to the southern plains of Extremadura and Andalusia. But some sixteenth-century evidence indicates that such extensive transhumance was not involved in the production of high quality merino wools from Segovia-based sheep. In any event, the evolution of fine merino wools was a rather slow process. Only in the very late fourteenth century, by the 1380s and 1390s, is their use first recorded abroad in commercial, export-oriented draperies: in the Italian draperies of Verona, Prato, and Florence. Even so they still ranked a poor fourth in value (at Prato), after English, Minorcan, and Majorcan wools, and then cost only 42 percent as much as the English Cotswolds wools used there.

In the Low Countries, Spanish merino wools were not used to any extent before the 1420s, and then only by the upstart semi-rural *nouvelles draperies*, which were making cheaper imitations of the luxury woollens manufactured by the larger traditional urban draperies. As England's finer wools became more and costly, in the fifteenth-century, for reasons to be explored in the following chapter, more and more draperies began switching to Spanish merino wools, even though they still could not yet rival in quality the finer English wools of the Welsh Marches and the Cotswolds (see below, pp. 000).

By the mid-seventeenth century, however, the better merino wools were clearly superior to all English wools: for the best Herefordshire Ryelands then sold for 3s 0d per lb., less than the average merino price of 3s 3d per lb. By that time, England's finer woollens were made wholly or in part from Spanish wools, as the name Spanish Medleys suggests. In the following century, Adam Smith caustically commented on the complete reversal in fortunes of these two historic wools, in his famous *Wealth of Nations* (1776):

Our woollen manufacturers, in order to justify their demand of such extraordinary restrictions and regulations, confidently asserted that English wool was of a peculiar quality, superior to that of any other country. This doctrine is, however, so perfectly false that English wool is in any respect necessary for the making of fine cloth, that it is altogether unfit for it. Fine cloth is made altogether of Spanish wool. English wool cannot be even so mixed with Spanish wool ... without spoiling and degrading the fabric of the cloth.

Worsted and worsted wools in medieval England

The mid-seventeenth century was also a transition era in the English cloth trade: when the export volumes of semi- and full-worsted products from the so-called New Draperies were beginning to surpass those from the Old Draperies, i.e. the more traditional woollen cloth industries. These New Draperies were not, in fact, related to the earlier Flemish *nouvelles draperies*, which had been a true woollens industry, but rather to the Flemish *sayetteries* and other *draperies sèches* or *légères*. From the late 1560s, with the outbreak of the Revolt of the Netherlands, many Flemish textile artisans found refuge in Norfolk and East Anglia (Suffolk and Essex), where they helped to establish or re-establish these worsted-style crafts, especially in and around Norwich, which had earlier been the very centre of England's medieval worsted industry (see below, pp. 000)

In the medieval era, this region had produced wools much below the national average in quality and price. Were these the same coarse and long-stapled worsted wools of the early-modern era, which then ranged from 15 to 25 cm (6 to 10 in), or longer? That seems highly unlikely, especially if Bowden is correct in stating that virtually all medieval English wools were short-stapled. Although support for his view can be found in recent research demonstrating the almost universally low weights of medieval English fleeces, there is still no conclusive evidence about the nature of yarns used in medieval English worsteds. Possibly, some

combination of breeding, flock managements, and environmental factors had permitted some variation in wool-staples; but that remains pure conjecture.

There are even more compelling reasons why -- apart from the importance of hybrid serge-type fabrics -- it would be dangerous to make too sharp a dichotomy between woollens and worsteds based merely on the staple-lengths of wool fibres. Certainly staple-length and fineness were not necessarily related. Many short-stapled wools, from many parts of the British Isles (and the continent) were in fact very coarse, and were used in both cheap woollens and worsteds or mixed fabrics. Conversely, some worsteds, says, and other mixed fabrics were woven from relatively better quality wools, so that they were more costly than many coarse woollens.

III. TECHNOLOGY AND TECHNOLOGICAL INNOVATIONS IN MEDIEVAL CLOTH-MAKING, TO C. 1500

Any history of the European wool-based textile industries also requires an understanding of the very crucial technological changes that the manufacturing processes underwent from the eleventh to the fifteenth centuries. Arguably such changes had an industrial impact that was relatively as important for medieval Europe as those of 'Industrial Revolution' era were for eighteenth- and nineteenth-century England. Certainly the medieval technological changes were more important than those of the intervening early-modern era (i.e. from c.1500 - c.1720). With the full fruition of those changes by the fifteenth century, the major stages of cloth-manufacturing had become the following, in sequence: (1) wool-sorting, scouring, and preparation, including preliminary wool-dyeing; (2) combing and carding; (3) spinning by the 'rock' and wheel; (4) weaving, on various looms; (5) fulling and tentering; (6) teaselling or napping; (7) shearing; and (8) dyeing or re-dyeing in the piece. Virtually all West-European words for textiles are derived, it must be noted, from the Classical Latin *textilis*, based on the infinitive *texere*, to weave; and any discussion of textile technology must, therefore, begin with this most fundamental and central process of cloth manufacturing, which was also the first process, or certainly the first of two, to undergo major technological changes.

Weaving: early-medieval worsteds and the warp-weighted loom

Throughout ancient and early-medieval Europe, and evidently also the Mediterranean basin, most weavers producing wool- and linen-based textiles employed an upright loom known as the warp-weighted loom, because the vertically-hanging warps were stretched taut by weights of stone, pottery, bone, or marble tied to their bottom ends ('end' = warp). Its framework, about three metres high, was composed of two wooden parallel uprights, whose tops rested against a wall or post. On forked crotchets at their upper ends was fitted a revolving cross bar, about two metres long, to which were stitched the upper warps ends; as the cloth was woven, it was rolled up onto this cross-bar by manual rotation. Near the bottom of the two uprights another cross bar, the 'shed rod', was rigidly fixed in place in order to divide the warps for weaving. Bundles of weighted warp-ends were alternately placed behind (below) and in front (or above) this rod, thus producing the natural shed or opening between the warps for the passage of the weft yarn. On another cross-bar, the moveable 'heddle rod', resting at the base of forked brackets half way up the two uprights, were knitted the heddles: i.e. linen cords with looped leashes or ends through which passed the individual rear warps. The weavers then lifted up the heddle rod on to the fork-ends of these brackets, thereby bringing the attached rear warps in front of the upper warps, locking the first weft in a permanent binding, while also opening the countershed for the second passage of the weft. The warps were kept evenly spaced across each shed by other cords, tied to the uprights, known as chains, from their fitted loops.

This loom required two weavers, who were almost invariably female in the ancient and earlier medieval eras. The first inserted the weft yarn, attached to a stick, through the natural shed of warps to the weaver standing on the other side; each weaver operated one end of the heddle rod, while passing the weft back through the countershed. After five or so weft insertions or picks, those wefts were beaten up through the warps and put firmly into place, into the fell of the cloth, with a long flat wooden or bone blade (about 50 cm) known as the 'spatha' or weaving-sword. An alternative device was the shorter weaving-comb (10 - 20 cm), a bone notched with teeth to fit between the warps.

The weave just described, by far the most common in the late Roman and early medieval eras, is

known as plain, tabby, or especially the linen weave, because it was used, then and later, for all linen and other bast-fibre weaves. It required just the two sheds, the natural and counter, with each weft passing under and over single warps, forming a regular binding -- i.e. the uniform interlacing of single warps and single wefts at right angles. A less common variant in this era was the basket or canvas weave, in which two wefts were together woven under and over two warps, in succession.

Increasingly popular from early medieval times, especially in worsted fabrics, were the various twill weaves, by which a single weft passed over two or more warps and then under one or more warps. That uneven alternation between weft and warps produced interruptions in the weave, or shifts of the binding-points, as the under pass of the weft in the alternate rows was moved one warp thread to the right or left, thus forming diagonal patterns. Such weaves required more sheds and thus a corresponding increase in the number of heddle rods. The most common of these weaves was the 2/2 (two over two) plain twill, using four sheds with three heddle rods: each weft passed over two warps and then under two, with a regular diagonal. Much more striking patterns, the most complex produced by the warp-weighted loom, were the related 2/2 broken-warp, chevron (herring-bone), and lozenge twills. In the first, the diagonals formed by the binding-points were asymmetrical, 'broken' at regular intervals; in the chevron, the direction of the diagonals was reversed (by reversing the order of lifting the heddle rods) over either groups of ends (warp-chevrons) or groups of picks (weft-chevrons); in the lozenge twills, the diagonals were so reversed to form diamond or lozenge shapes, by a combination of warp-chevron and weft-chevron twills.

Indeed this ancient loom seems to have been best suited to the production of worsted or semi-worsted textiles. For the overwhelming majority of the few preserved early-medieval textiles (c.700 to c.1100 AD), excavated in Scandinavia, the Baltic basin, and eastern Europe, are worsteds, with the typical Z-spun twists for both warp and weft, high warp-counts, very low weft to warp ratios (at least a 2:1, in contrast to true woollens, with a 1:2 or 2:3 ratio); light weights, unfulled and unshorn textures; and thus clearly distinguished weave patterns, especially with these very same chevron and diamond/lozenge twill designs.

The ancient and early-medieval worlds, however, also employed two other textile looms. The less important, though closely related, form of weaving, involved tablets: square plates of bronze or bone, with holes in the four corners for passage of the warps. One end of the bundle of warps was tied to a post, and the other to the weaver's waist. These tablets were often used in a series, hand-held like a pack of cards. The sheds for the wefts were changed by turning the tablets backwards or forwards, at the same time twisting the warps into cords, which were held together by the wefts. Tablet-weaving was in fact particularly important for producing starting borders on the warp-weighted loom, to provide an especially strong anchor for the warps; such warps (for the rest of the cloth) were in fact the wefts of that border. The more important alternative was the 'Roman' two-beam vertical loom: a wooden structure about two metres high, free-standing and secured to floor-blocks. An ancient instrument of evidently eastern origin, this loom was probably introduced into Europe via Egypt during the first century, when it was first described by Seneca. Its upper beam similarly served as the anchor for the warp yarns, which were passed over a shed rod to be wound, from the back, around a revolving lower cloth-beam, which was rotated with levers to wind up the woven fabric. Consequently, the seated weaver beat the weft down, rather than up, into the fell of the cloth, usually with comb-beaters. This loom became and long remained important for tapestry-weaving in medieval and early-modern Europe; but for other textiles, it did not supplant the warp-weighted loom, in part because the warps lacked flexibility and the sheds were necessarily very narrow. Certainly in northern Europe, the warp-weighted loom remained predominant, until about the eleventh or twelfth century, when documents first indicate the presence of a very different new loom: a horizontal loom with foot-powered treadles.

An industrial revolution in woollen textiles: the horizontal loom

It was first described in an eleventh-century Talmudic commentary by Rabbi Solomon Izhaqi, better known as Rashi of Troyes (c.1040-1105), as a new loom 'by which men weave with their feet'. Like so many textile implements, its origins were probably Oriental. Its ultimate source may have been China, where a similar device had evidently been employed in silk-weaving from at least the first century A.D.; and such a

loom was evidently also used for silk-weaving in the Byzantine Empire, though none has yet been found with the all-important foot treadles. Thus, the loom that Rashi so described may have entered Europe from the Byzantine Empire or from Muslim Spain and Sicily (where it may have been used as well for cottons) during the early eleventh century.

This new loom was a vital component in what might also be called a combined economic and fashion revolution that commenced in this very same era: the emergence and spread of the true woollens, i.e. heavily fulled, felted, and shorn cloths, with a consequent shift away from the worsted-type textiles just described. Although some worsted-type fabrics woven on the warp-weighted loom had indeed been quality products, many of the new shorn woollens, evidently woven on this new loom, were even more luxurious cloths, the very best of which were, of course, woven from the finer, shorter-stapled grades of English wools. In so far as this new loom was so much more effective than its warp-weighted predecessor in producing these new and more truly woollen cloths, it was all the more pivotal in the history of medieval textiles: in influencing if not necessarily determining the nature of many other innovations, new modes of industrial organization, and radical changes in the social composition of medieval cloth manufacturing.

The original European version of the new horizontal treadle loom had a narrow, box-like construction with a raised seat in front for the weaver. The warps were stretched taut horizontally from a warp-beam in the rear to a cloth beam in the front, both of which were rollers on ratchets rotated by a hand-lever. Instead of the shed and heddle rods, this loom utilized heddle-harnesses, which were suspended from pulleys hooked to the upper cross beam of the loom and operated by foot-powered treadles (levers) underneath the front of the loom. The harness itself was a rod to which were attached the numerous heddles or healds, similar to those in the earlier looms: i.e. linen cords with looped ends through which were passed the individual, alternate woollen warps. Each weaving shed had its own heddle-harness, pulley, and treadle: thus, two sets of each for plain (tabby, linen) weave; three sets, for $\frac{1}{2}$ or 2/1 twills; and four, for the 2/2 twills.

Completing this horizontal loom were the actual weaving instruments: the laysword (or sley) and

reed, joined together and similarly suspended from the upper cross beam and placed between the heddles and the front of the loom. The laysword's moveable frame contained a grooved wooden channel for the passage of the shuttle, a complementary innovation, which encased the weft yarns wound on to a spool. As the shuttle moved along the laysword, the weft unravelled and passed through a hole in its side. Attached to the front of the laysword, parallel to the shuttle-channel, was the reed, also known from previous looms as the beater or woolcomb. Encased in a heavy wooden batten, it consisted of two narrow horizontal strips of wooden laths joined together by a multitude of evenly spaced, thin, vertical wire teeth, much like the teeth on a comb. The individual warps or groups of warps were passed between these teeth, which thus kept them equidistant and parallel during weaving, ensuring the proper width of the cloth, much more efficiently than had the chains in the warp-weighted looms.

On this new loom, weaving commenced with warping, handled by the weavers' female assistants known as warpers, with a method very different from that of the antique looms. After spinning, the warp yarns had been wound into cops onto bobbins that rotated on pegs fixed to a wall or posts. The warpers unwound the yarns from a dozen of these cops, passed them through a hole in a hand-held board to group them tightly together, and then wound that group of yarns onto wooden pegs fixed to the upright warping-board, in zig-zag fashion from top left to bottom right and back to the first peg. In fourteenth-century Flanders, France, and Italy, such yarns were usually wound in groups of twelve, which, when so doubled into twenty-four, were designated as *portées* (French), *ganghen* (Flemish), or *portate* (Italian), so that, for example, a requirement of 78 *ganghen* = 1872 warp yarns (Ypres 1365). The warps, thus measured for the proper length on the loom, were cut, wound into skeins, and then sized in a glue-bath to strengthen them for the ensuing weaving processes. After winding the sized yarns onto the loom's removable warp beam, the warpers then inserted several metres of warp ends through the loops of the heddles (alternating sets for each harness), then through the teeth of the reed, and finally tied them onto the cloth beam, stretching them tautly. A high-quality woollen broadcloth contained about 1,700 to 2,000 warps (a count nevertheless *lower* than

that for many worsteds, with far more tautly spun warp yarns).

The weaver, when commencing a simple two-shed tabby weave, depressed the left treadle to raise the right heddle-harness and thus open the natural shed of even-numbered warps, for the first interlacing. He (less commonly she) then slung the weft-bearing shuttle through the grooved laysword with the right hand, grasping it at the other side with the left, and pulled it through the shed, thus unwinding and inserting the weft; with the first 'pick' so inserted, he then pulled the laysword with reed and batten to the front of the loom, in order to beat the weft up into the fell of the cloth. Next, he depressed the right foot-treadle to raise the left treadle and harness, locking the first interlacing or binding, while opening the countershed of odd-numbered warps for the second passage of the shuttle. Repeating the steps just described, the weaver periodically thereafter used levers for the appropriate beams, to feed out more warps or to wind up the woven cloth.

This horizontal loom provided a number of significant advantages over the older vertical looms, especially the warp-weighted. First, it produced a uniformly better quality, more densely woven woollen (or other fabric), with proportionately more weft than warp (i.e. warp:weft ratios of 1:2 or 1:3), by stretching the warps much more tautly on the two beams, with more even tension, and by beating up the wefts more firmly and evenly than on the warp-weighted or other looms. Secondly, weavers, even single female weavers, found that the treadle-operated heddle-harnesses vastly improved their control over the weaving-sheds for all types of cloth, plain and twilled (especially with 2/1 and ½ twills). Thirdly, by using two separate revolving beams, for winding on the warps and winding up the cloth, this new loom could produce cloths of far longer lengths: 25 to 30 metres or more. Fourthly, the horizontal loom permitted a large increase in productivity, eventually a more than three-fold increase (up to 390 metres of weft per hour, compared to about 120 metres with warp-weighted loom). But further improvements in loom design were also partly responsible for such productivity gains.

The chief limitation of the original horizontal loom was that it was too narrow, limiting the cloth

width to the arm stretch of the single weaver, while the warp-weighted looms, utilizing two weavers, one on each side, had long been producing cloths of two metres (yards) or more in width. For this reason, along with various other factors that inhibited the acceptance of technological innovations in the medieval era, this new loom did not succeed in displacing the old for perhaps two centuries or more, until the development and diffusion of the horizontal broadloom, designed to weave woollens from two to three metres wide.

Various historians have stated, without any documentary foundation, that the broadloom was a Flemish innovation of the mid-thirteenth century; but it probably evolved much earlier (there or more likely elsewhere). In its fully developed broader form, its box seat or bench now accommodated two weavers who, seated side by side, individually operated a set of treadles, pulleys, and heddle-harnesses, but together manipulated the shuttle and the combined laysword-reed-batten. The first weaver slung the shuttle along the laysword with his right hand towards the outstretched left hand of his partner, who repeated these movements in reverse, in a constant rhythm, without alternating arms, thus permitting a much more rapid weft insertion per unit of width.

If the resulting increase in productivity was no doubt impressive, as was the improvement in quality, we should place those gains in proper perspective. In late-medieval Flanders, weaving a standard broadcloth of 42 ells by 3.5 ells ($29.4\text{m} \times 2.45\text{m} = 72.0\text{m}^2$), containing 84 lb. or 38.2 kg of wool (16.3 kg of warp and 21.8 kg of weft), typically required about twelve days or more. Another dozen or so days of labour were expended in wool-beating, wool-greasing, carding, combing, spinning, reeling, and warping the yarns for the same cloth, involving about 26-30 artisans and helpers. With perhaps 210 - 240 working days a year, annual output averaged about 20 such broadcloths per loom, with an upper limit of perhaps 25-30 broadcloths. To this we must add the finishing processes of fulling (three or four days per broadcloth), napping, shearing, and dyeing (several days). Productivity in weaving, at least, did not significantly increase again before the Industrial Revolution era. According to a report presented to Parliament in the 1780s, weaving a superfine broadcloth of 34 yards (i.e. before fulling), with 70 lb. of wool (31.8 kg), then required 364 man-hours (= 14.5

days, with two men and a boy), and a further 888 man-hours in wool preparation, spinning, reeling, and warping.

Finally, if the new medieval broadloom did eventually displace the warp-weighted loom in most parts of Europe (except northern Scandinavia and Iceland), it did not supplant the narrow, single-weaver horizontal loom, which retained two advantages: it cost much less to build, operate, and maintain; and it allowed the skilled weaver to work unimpeded by a potentially careless or delinquent partner. The single or narrow loom long remained the preferred method for weaving the smaller, less densely woven, cheaper woollens; and certainly it was used for most true worsteds, most of which were narrow fabrics. Furthermore, as noted earlier, the upright tapestry loom continued in use, not only for weaving tapestries, but also for producing very small, cheap cloths, such as English and French *chalons* and *tapets* (measuring 3 to 4 yards in length).

If the horizontal loom, evolving into the broad loom, was undoubtedly the single most important innovation in the development of the true woollen and the medieval woollen industry itself, there were at least three other innovations that led to considerable productivity increases, in both yarn preparation and cloth-finishing: carding, wheel-spinning, and mechanical fulling. The latter two in particular have received more (and often misleading) attention in the literature than the technological changes in weaving; but unlike those for weaving none of these changes produced any noticeable, let alone dramatic, improvements in the quality of woollens. On the contrary, their introduction was widely opposed in the medieval woollens industry, especially on the continent, not because their use would create 'technological unemployment' but rather because such uses impaired the quality of very fine woollens.

Combing, carding, and bowing:

Though many English textile histories leave the impression that *medieval* woollens were always woven from wheel-spun carded wools, in historical fact, from ancient times through much of the medieval era, all wools had been prepared instead by combing, and then spun with the distaff and drop-spindle: i.e. both short- and longer-stapled wools, for both warp and weft, and woollens as well as for worsteds. The combs

so used across medieval Europe varied considerably in forms and dimensions. Our best documentary evidence, from the later-medieval Flemish draperies, indicate that the preferred form for woollens was a T-shaped comb, with three rows of seven teeth of finely tapered steel, that were about 14 in. or 36 cm long; but a smaller comb was evidently used for wools in making *sayette* or worsted yarns. They were used in pairs, with the back of the lower comb placed on the knee or fixed to a wooden post. The wool was placed on the upward-facing teeth, and the upper comb (teeth facing downward) was then drawn across these teeth several times until all the wool had been transferred to this second comb. This procedure, repeated several times, disentangled the wool fibres, and separated the longer fibres from the shorter ones (noils), which usually curled around the base of the teeth, and aligned them for spinning.

Subsequently, for the preparation of short-fibred wools, carding was introduced as an alternative technique, one that was probably borrowed from the Islamic cotton industries of Spain or Sicily during the later thirteenth century (possibly earlier in Italy). According to some historians, carding can be found in southern Italy (Apulia) from the mid-eleventh century and in Portugal from the twelfth century; but the evidence is not clear that these were cards for wool-preparation or fullers' cards used in teaselling the cloth (see below, pp.). The true wool-card itself was a rectangular leather-covered board, about 30 cm by 15 cm (12 by 6 in.), through which were inserted hundreds of fine, short, sharp hooks or wires bent towards the handle, so that the instrument resembled a wire-brush. Like the wool-combs, these cards were used in pairs, with the hooks working in opposite directions. The carder placed the wool on the teeth of the upward-facing lower card and then drew or brushed the other card through the wool several times until it had been fully transferred. Carding thus disentangled and aligned the wool fibres, indeed separating and multiplying the strands more effectively than did combing, but without removing the very short fibres. Carding, furthermore, allowed the short, curly, serrated fibres to protrude and become crisscrossed in a spongy, soft, air-filled cylinder (called a *rolag*), thus promoting their natural felting properties. Carding also proved to be very effective in blending together a variety of wools, particularly variously dyed wools. Combing, on the other

hand, remained the superior method of preparing those longer-stapled worsted-type wools that required parallel formation to give spun yarns their necessary twist and strength.

Nevertheless, rather surprisingly, combing also remained mandatory for the short-fibred wools in many traditional and even the newer woollen industries. In some European towns, carding was or came to be totally banned: in Paris (1273), Lier (1332), Valenciennes (1358), Ghent (1350), Douai (1352), Leiden (1363), Mechelen (1364), Brussels (1365). Many of these and other towns, however, did permit carding in their non-sealed, cheaper-line draperies, especially producing for local or regional consumption. In many other draperies -- in Italy, France, and the Low Countries -- carding came to be forbidden for only the preparation of the warps; and thus implicitly if not explicitly it was permitted for the wefts: in Florence (1317), Saint-Omer (1350), Troyes (after 1377), Ypres (before 1363). Indeed, such a dichotomy is reflected in the later-medieval Italian, French, and Flemish textile terminology for carded and combed yarns: they are precisely the same as the terms for weft (*lana*, *trame*, *wevel*) and warp (*stame*, *estain*, *waerp*), respectively. Nevertheless, carding in any form was diffused very slowly throughout western Europe; and even the relatively new Leiden drapery (established c.1363) consistently banned carding for wefts as well as for warps, up to its late sixteenth-century virtual demise (see below, pp.).

An alternative technique that much resembled carding in the preparation of short-fibred wools for weft yarns was 'bowing' (*arçonnage*), which evidently entered western Europe about the same time as carding, and possibly even earlier, possibly via the Muslim cotton-linen fustian industries of Sicily. Indeed a cotton-bow was evidently employed in the fustian industries Norman Sicily and Apulia as early as the twelfth century. Some historians have conjectured that bowing came from eastern European fur- and felt-hat making, for which an almost identical bow continued to be used for centuries. The bow itself was a long elastic, arched framework of wood whose centre was suspended by a cord from the ceiling, and whose two ends were connected by a tautly stretched string or catgut cord. The bow-string was set in the middle of a pile of cotton, short-stapled wool, or fur, and was struck by a mallet to produce vibrations that forced the

fibres to separate. In general, the results were similar to those from carding, in particular to promote the wools' felting properties. In Chorley's view (1997), 'bowing was a far more important and widely used technique than the traditional literature suggests'; but the evidence for any widespread use in west European draperies is very slim. Nevertheless, despite the paucity of evidence, one fact about bowing remains significant: it never encountered the hostility and bans that were inflicted on carding.

Why carding was so rigorously restricted for so long in so many places is a mystery, though the answer may lie in the word's etymology. The term card, from the Latin *carduus*, a thistle, originally meant, as suggested earlier, an important instrument used by fullers and shearers: the teasel (teazel, teazle: *Dipsacus fullonum*), a prickly thistle-plant used to raise the nap or protruding fibres on felted cloth. Metal cards, which some fullers had evidently tried to use for this purpose as well, were universally and strictly banned in the cloth-finishing processes, on the understandable grounds that their iron teeth might damage the woven cloth. Perhaps, therefore, these cards were also banned in wool preparation for fear that they would similarly damage wool fibres; but an equally possible reason was to prevent their use in fraudulently blending cheap, inferior wools with the good.

Nevertheless, such restrictions on carding were neither universal nor immutable. In England, carding was officially recognized by statute in 1464 (4 Ed. IV c. 1); and no prior English restrictions have been documented, though at least two historians have noted the use of combed woollen-warp yarns in English draperies of this same era. In the southern Low Countries, where semi-carded woollens (i.e. those with combed warps) had become standard by the later fourteenth century, two changes can be documented in the following century. In the very prominent Mechelen drapery, its finest broadcloths were described, from 1435, as *gecaerde lakenen*, a term that possibly meant those made wholly from carded wools, rather than just those with carded weft yarns (despite doubts expressed in Chorley 1997). Brussels, which had long forbidden carding except in the petty draperies, altered its drapery regulations in 1467 to permit the use of wools 'either combed or carded', without any restrictions concerning warps, in the best luxury quality broadcloths, even

in the immensely costly *scaerlakenen* (scarlets), as the individual draper saw fit, so long as those wools continued to be ‘good English Staple wools’, specifically fine March, Cotswolds, and Lincolnshire (Lindsey) wools. Nevertheless, among many others, the draperies of Ghent and Armentières, the latter relatively ‘new’, continued to use combed woollen warps exclusively, as did the Florentine and other Italian draperies.

Still unanswered therefore is this major question: why did so many leading draperies continue to ban carding for warps, while permitting it for the wefts? The warps, as already noted, necessarily had to be the much stronger yarns, to withstand the stress of being stretched between the two roller beams and also by the warp-shed heddles. Carding may not have permitted sufficient twist and thus strength in spinning warps, a point that may now be clarified in analysing the associated innovation in spinning.

Spinning: distaff, drop-spindle (rock) and the spinning wheel

Spinning is the art of converting combed or carded fibres into yarn by a three-part process that became fully continuous only in the fifteenth century: (1) drafting or drawing out the fibres from the mass of prepared wools; (2) twisting the fibres to cling together and to form one continuous yarn; and (3) winding that spun yarn onto a spindle or bobbin. From ancient times, the most common method was hand-spinning, aided by the distaff and the spindle-whorl. The former was a narrow forked or cleft stick, to which was fixed the mass of raw wool fibres. The latter, commonly called a ‘rock’ (*roc*, *rocca*), was a rod tapered at both ends, and inserted through a disc-shaped whorl of stone, clay, bone, or wood, which served as a fly-wheel to make the spindle drop vertically and rotate rapidly in one direction. The larger, heavier rock-spindles were used for spinning linen and worsted yarns; and lighter spindles, for true woollen and cotton yarns. Those using this drop-spindle were thus commonly known as rock-spinners.

The spinner, attaching some leading fibres from the wool on the distaff to the spindle, let it drop with a sharp twist to its top, and then drew out more fibres from the distaff with one hand, while using the other to control the yarn's twist. The yarn so spun could be very strong, yet very thin and quite even throughout. The degree of fineness and twist was determined by the weight of the spindle-whorl, the extent of its drop,

and its rotation speed, while the yarn's uniformity depended on the spinner's manual dexterity. A counter-clockwise rotation in drafting and twisting (right to left) produced S-twist, for linen, cotton, and woollen weft yarns; conversely, a clockwise rotation (left to right) produced Z-twist, for hemp and worsted yarns and combed woollen warps, with a tauter, stronger yarn.

The subsequent European adoption of the famous spinning-wheel involved quite simply the mechanization of this spindle, which was mounted horizontally as an axle between two short slotted uprights, with one tip protruding. The former disc or whorl, fixed at the centre of this spindle-axle, now became a grooved pulley to receive a continuous driving band or cord from the wheel, also mounted on an axle and rotated by hand: if the band was crossed before encircling the whorl, in figure-eight fashion ('closed band'), an S-twist yarn was produced; if it was uncrossed ('open band'), then Z-twist resulted. The larger the wheel, the faster would be the spindle's rotation by this belt transmission of power. A spinner could easily rotate the so-called Great or Indian Wheel, with a 1.14m diameter (45 in.), 100 times a minute (100 rpm) to produce 3,600 rpm in the spindle, for a large, perhaps three-fold, increase in labour productivity over the traditional drop-spindle method (about 350 m of yarn per hour vs 110 m).

Otherwise the new machine did not change the basic principles of spinning. Drawing some fibres from the raw wool fixed in the distaff, the spinner attached them to the protruding spindle tip; and, rotating the wheel clockwise with the right hand, she drew the distaff with the carded wool slowly away from spindle tip. The spindle's very rapid rotation and the resulting tension drafted and attenuated the fibres, which spiralled up to the spindle tip and then slipped off, thus twisting the yarn as it was spun out. By increasing the angle of the drafted fibres to the spindle-tip (from 45° to 90°), the spinner tightened the twist. Having drawn the distaff out the full length of her arm, the spinner then stopped, and used the wheel to wind the spun yarn slowly onto the spindle shaft near the upright.

This spinning wheel was evidently also Oriental in origin, probably entering western Europe from the Muslim cotton industries in the later twelfth or early thirteenth centuries, when it was first used to spin

cotton wefts in the Italian fustian industries (see below, pp. 000). Its original small wheel continued to be used for cotton, while the later Great Wheel came to be used for wool-spinning. The spinning wheel is first documented in woollen manufacturing only in the next century when, like carding, it was either banned outright or forbidden for warp-spinning, beginning in Italy: in Venice (1224), Bologna (1256), Paris (1268), Speyer (1280), Abbeville (1288), Siena (1292), Douai (1305). These bans, partial or complete, then multiplied with the spread of the spinning-wheel, especially in the Low Countries, and remained in force until the later fifteenth or sixteenth century. Bans on warp-spinning were more frequent; and they generally also contained the afore-mentioned prohibitions on carding wools for warps. Such ordinances therefore, implicitly or explicitly, did permit the spinning wheel to be used for carded woollen wefts.

These bans were hardly intended to protect the hand-spinners from technological unemployment, not when most were unorganized and exploitable women, often rural, but rather to protect the quality of especially the finer grade woollens. In spinning warps, the new spinning wheel was quite inferior to the traditional drop-spindle. Because of the wheel's great speed, and the spinner's inability to control drafting and twisting (with her right hand occupied in rotating the wheel), the warps so spun were generally too weak, too uneven, with insufficient twist, and with 'too many knots', according to the *Livre des mestiers*, composed at Bruges c.1349. Thus too often wheel-spun warps were unable to withstand the considerable stress imposed upon them when stretched on the loom and forcibly separated by the heddle-harnesses. Since such defects were not so serious with weft yarns, the spinning-wheel, with its obvious superiority in productivity, soon gained supremacy in European weft spinning for both carded wools and cotton; and the *Livre des mestiers* explicitly confirms that wheel-spun yarns cost much less to produce than 'rock'-spun yarns. Evidently, therefore, the wheel was better suited to carded than to combed wools, while conversely the drop-spindle was better suited to the combed wools, to explain why so many or even most late-medieval woollens had combed rock-spun warps and carded wheel-spun wefts.

The Saxony wheel

Not until the close of the Middle Ages were combed wools or combed flax (linen) commonly spun on the wheel, and then only on a radically improved version, the so-called Saxony Wheel, which permitted the simultaneous drafting, twisting, and winding-on of the yarns. Formerly dated to c.1530 and attributed to Meister Jürgen of Brunswick, Lower Saxony, this new spinning wheel has since been found, almost fully evolved, in late fifteenth-century drawings (in *Das Mittelalterliche Hausbuch* of Waldburg-Wolfegg, Lake Constance, c.1475-80; and in Leonardo da Vinci's *Codice Atlantico*, c.1490). Some scholars suggest that textile artisans in fifteenth-century Italy had adapted features of this new wheel from silk-throwing machines.

Its radically new device was the two-armed or U-shaped flyer, fixed securely on the spindle-axle, to the left of the drive-pulley, rotating directly with it. Fitted loosely on the spindle, between the two arms of the flyer, was a bobbin with its own but much smaller driving-pulley, which rotated much more rapidly than the flyer and spindle. A continuous driving belt was looped twice over the driving wheel, once over the spindle's pulley, and then once over the bobbin's pulley. The lead yarn, drawn from the distaff (now fixed to the frame), was fed through the front end of the hollow spindle, out through a hole in the side of the shaft underneath the flyer arms, and then over hooks on the flyer, which guided the yarn onto the bobbin. The spindle's rotation drafted the fibres, while the flyer twisted the yarn with each revolution, and then wound it directly onto the more rapidly revolving bobbin – now all in one continuous movement.

Other important features, some added subsequently, were: a treadle, with crank and axle, to power the driving wheel by the foot; a 'tensioner' or wooden screw in the base to adjust the tension on the drive-band by moving the flyer-spindle away from or closer to the wheel; and, for the drive-band, a doubled-grooved spindle-pulley, with the deeper groove for spinning warps and the other for wefts. Both hands of the now seated spinner were thus fully free to guide the fibres into the spindle orifice, to adjust the tension on the driving band, the hooks on the flyer, and the speed of the bobbin, thereby governing the yarn's degree of twist and uniformity. For Z-twist yarns (warps), the wheel was turned clockwise; for S-twist yarns (wefts), counterclockwise, with the same drive band.

Evidently this new spinning wheel was at least twice as productive as the old, certainly in wool-spinning. Though productivity gains were apparently less in flax-spinning, the Saxony wheel soon became predominant in the West European linen industries. A few historians have contended, furthermore, that in the early-modern era it was used for spinning only linen and worsted but not woollen yarns. That view seems to be contradicted by the double-grooved pulleys (for warps and wefts); it certainly remains unsubstantiated or supported by other scholars, some of whom also contend that the Saxony wheel produced much higher quality yarns than the traditional wheel in the woollen industry. Furthermore, its use in the woollen industry is portrayed in some early sixteenth-century Flemish and Dutch paintings, those by Jan Van Galle and Lucas Van Leyden (1494-1533): with appropriate wool cards, teasel-frames, and cloth-shears. Since the Saxony Wheel's smooth, continuous actions were those requisite for spinning carded wools, as well as combed, one might conjecture that this machine was responsible for producing, finally, high-quality all-carded woollens, by the mid-fifteenth century; i.e. the previously mentioned examples from Mechelen and Brussels (1435-1467). Indeed, in 1467, the Brussels drapery, in rescinding the ban on carded yarns, also revoked its long-standing bans on the use of 'wheels' in spinning woollen warps, as did the Leuven drapery shortly thereafter.

Nevertheless any such relationship between the advent of the Saxony-type wheel and wheel-spun carded woollen warps remains only conjectural. Certainly the woollen industries long continued to employ the traditional 'Great Wheel', which long predominated in spinning fine carded woollen wefts; possibly, furthermore, spinners using this Great Wheel may have finally improved their techniques to produce strong carded woollen warps that were acceptable to most of the finer-quality west European draperies. Chorley (1997) suggests that the Leiden drapery, after staging a successful revival with new products in the 1630s (see below pp.) perfected such a technique, but he offers no viable explanation for this crucial transition in European spinning.

Fulling and the fulling mill

For many historians, especially Carus-Wilson (1941, 1952, 1987), the most important and most

dramatic textile technological innovation of the medieval era was the water-powered fulling-mill. Though achieving its true importance by complementing the new horizontal loom, it may have been the earliest of all the textile innovations discussed in this chapter. For Malanima (1986) and other historians have documented such mills in Italy, from the later tenth century: at Abruzzo, 962; Parma, 973; Verona, 985; and Lodi (near Milan), 1008. In northern Europe, the first known fulling mill was established at Argentan, Normandy, in 1086. Fulling was also the only process to be mechanized by water-power before the fifteenth-century introduction of gig-mills for nap-raising (see below pp.), and indeed the only important process to be so mechanized before the eighteenth-century Industrial Revolution.

The traditional process that fulling-mills were designed to displace, the very labour intensive technique of foot-fulling, seems to have been a rather cursory and perfunctory process in the Roman Empire and early medieval West, designed more to degrease and cleanse cloths than to felt them. But during the later Middle Ages, and thus after the introduction of the first fulling-mills, foot-fulling became increasingly complex and much more prolonged, especially in the major traditional draperies: a much more crucial process that completed the manufacturing and commenced the finishing processes, vital in determining the luxury quality of the finer woollens. For many of these traditional urban draperies, that growing complexity of foot-fulling may help to explain, along with other reasons to be explored later, their reluctance to mechanize this multi-staged process. Therefore a true understanding of this industrial innovation and the resistance it encountered will depend upon a brief analysis of foot-fulling, according to various drapery texts from the fifteenth-century Low Countries.

First, on receiving the woven cloth from the loom, the fullers placed it in a large tub containing an emulsion of warm water and fuller's earth (*floridin*, with hydrous aluminum silicates, usually *kaolinite* $\text{Al}_2\text{O}_3\text{Si}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$); despite widespread prohibitions, urine was commonly also added. Then a pair of husky journeymen fullers (i.e. male), supervised by a master, vigorously trod upon the soaking cloth, initially to scour and cleanse it: to remove the large amount of grease, warp sizing, and dirt that it necessarily contained.

The ammonia in the urine not only enhanced the scouring and bleaching properties of fuller's earth but also combined with the grease to form a cleansing soap. These scouring agents also made the wools more receptive to the dye-fixing mordant, usually alum, when the cloth was subsequently dyed in the piece. Next, the soaking-wet cloth was hung on a pole or frame for 'burling:' the removal of any knots and other defects produced by weaving and scouring. Then, while still draped over this pole, it was subjected to a preliminary form of felting (*forbattage*), somewhat akin to carding, by brushing both sides of the cloth with teasels, to force any loose fibres to the surface and to promote a preliminary interlacing. The cloth, given another greasing with lard or butter, was then put back in the vat, with hot water, soap, and subjected to proper fulling, with far more vigorous trampling, to force the short, scaly, curly wool fibres to interlace and shrink. Finally, after the cloth had been fully felted, it was thoroughly rinsed clean.

In 1458, the Bruges fullers' ordinance for *bellaert* woollens stipulated that the overall shrinkage from this compression and felting, which gave the cloth its required strength and durability, had to be at least 56 percent (from 172 to 75 square ells): in length, from 43 to 30 ells (30m to 21m); and in width, from 4.0 to 2.5 ells (2.8m to 1.75m). The better known Ghent *dickedinnen*-broadcloths of the fifteenth and sixteenth centuries (1456, 1462, 1546) underwent a very similar shrinkage, of 54 percent (from 75.49m² to 34.91m²). In both, and indeed in all such woollens, the width underwent greater shrinkage than the length (37.5 vs 30.2 percent), because the warps were more tightly spun than the wefts.

Virtually all the major draperies, and especially those in the Low Countries, retained this labour-intensive foot-fulling up to the sixteenth century. Fulling a standard-sized luxury quality woollen broadcloth, such as the Bruges *bellaert* just described, took from three to five days, depending on the cloth type and the season (since the summer workday had twelve hours, while the winter workday had only eight hours). For each fuller (two per vat working from 210 to 240 days a year), the maximum annual output ranged from 21 to 40 broadcloths, averaging perhaps 30 to 35 cloths. Cheaper and smaller woollens required no more than two days fulling; and most serge-type and semi-worsted fabrics, only a day's fulling (about 9-10 hours) --

more for scouring and cleansing than for any real compression and felting.

But, as just noted, water-powered fulling-mills had superseded these traditional methods from a much earlier era in many other parts of Europe, most especially in Italy and England. The first English fulling mill to be recorded was established at Paxton in Huntingdonshire in 1173, followed in 1185 by two mills of the Knights Templar, at Newsham in Yorkshire and Barton in Gloucestershire (Cotswolds); thereafter, for the thirteenth and early fourteenth centuries, various historians and historical geographers have now documented a widespread diffusion of such fulling mills, even in the flatter lowland regions of eastern England.

Using a water-wheel to power hammers that fulling the cloth was obviously a far more complex process than using such power to grind grain into flour, its most widespread use, since the rotary power of the waterwheel first had to be converted into reciprocal or up-and-down power. The technological principles for doing so were, however, evidently known as far back as Alexandrine times: by the use of cams, as small projections fixed along the water-wheel's main axle. Thus, as the large water-wheel revolved, the cams in turn rotated a smaller drum with wooden cam-tappets protruding from each side, which periodically made contact with similar grooved-projections on two large, heavy oak trip-hammers. As the wheel and its attached drum rose, the drum's cam-tappets raised one of the trip-hammers; and as the wheel began its descent, the cams passed by the trip-hammer's projections, thus releasing the hammer to fall with immense force into the fulling trough far below, while other cams on the revolving drum made contact with the second trip-hammer, repeating this process. The two trip hammers could pound the cloth up to forty times a minute; and, with just one attendant, they could scour and full a standard-sized good quality woollen cloth in about twenty hours, though requiring only about nine hours for lesser quality cloths.

By the later Middle Ages, two types of vertical water-wheels were used to power fulling mills, each with its own set of advantages in costs and productivity: the undershot and overshot wheels. The former was the first to be used; and, as the name undershot suggests, it was driven directly by the flow of the water underneath, acting on paddles or flat radial blades fixed to the circumference of the wheel. Its power thus

depended essentially upon the speed of the river's current; and its efficiency has been estimated at just 15 to 30 percent of the potential power of the flowing water. Very simple and cheap to build, undershot waterwheels could be placed on any suitable stream or river, fast or slow, without mill-races (i.e. narrow artificial channels to concentrate the water); but obviously they produced far more effective power on faster-moving streams with some significant gradient.

Introduced much later as an alternative form of water-power, the overshot wheel required a mill-race in the form of an elevated aqueduct or sluiceway that fed a stream of water to the very top of the waterwheel, where it poured into inclined buckets or receptacles fixed into the circumference of the wheel. Thus the weight of the water in these buckets, rather than the speed of the flowing water, caused the wheel to rotate; and the wheel's descent emptied these buckets near the bottom of the revolution, to be refilled once more as they reached the top. If well constructed, the overshot wheel was more than twice as powerful as the undershot wheel: i.e. its efficiency ranged from 50 to 70 percent of the potential force of the water as it struck the wheel, requiring only about one-quarter as much water as undershot wheels. Obviously, its relative efficiency was even greater on slower moving streams and rivers, provided that suitable dams and storage ponds, aqueducts, and mill races could also be constructed to project the water over the wheels with a sufficiently forceful 'head' or 'fall'. Therefore, the much heavier capital investment involved in its construction and higher maintenance costs to some extent offset the gains in relative power and efficiency.

Precisely when these overshot wheels were first introduced into Europe remains uncertain. Wall-paintings from Roman catacombs and archeological evidence from Barbegal, in southern Gaul, dating from the third century AD, provide good indications though not positive proof for their use. In England, the earliest evidence for the overshot wheel is its very accurate depiction in the famous Luttrell Psalter of 1338; and archeological evidence from the mid-fourteenth century indicates that a water-mill at Batsford in Sussex, on a slow river, used an overshot wheel. Nevertheless, from an examination of drawings and iconographical evidence, Usher (1954) has estimated that undershot wheels greatly outnumbered overshot wheels until the

early sixteenth century; and subsequent research by Reynolds (1983) confirms this view. Domesday Book (1086) indicates that a significant proportion of the 6,082 recorded watermills were located in the chiefly lowland eastern counties of Lincolnshire, Norfolk, and Suffolk; and thus we must assume that these and subsequently recorded water-mills on slower-moving streams and rivers used undershot rather than overshot wheels. A map of medieval fulling mills produced by Pelham (1958) does indeed show some fulling mills in East Anglia, though by far the greater concentration of medieval fulling-mills was in the more highly elevated western and north-western counties.

Obviously no one would have built, and no clothiers would have leased or paid to use, these medieval fulling mills unless they provided significant gains: i.e. economies on labour costs that would offset the obviously large capital investments (and maintenance costs) required. Estimates of the productivity gains and cost savings achieved by substituting mill-fulling for foot-fulling vary enormously. But the most recent and most reasonable is that provided by Van Uytven (1968, 1971, 1981) for sixteenth-century Brabant: a 70 percent saving by mill-fulling, for a 3.3 fold productivity gain, an estimate supported by other independent evidence. Thus the cost of foot-fulling a standard sized broadcloth at Leuven and Leiden (in the 1430s) amounted to 20 per cent of total pre-finishing, value-added manufacturing expenses, while the cost of mill-fulling the same sized cloth at Florence (in the 1550s) accounted for only 5 percent of such manufacturing costs, for the equivalent-sized woollens, thus indicating a 75 percent cost advantage for mill-fulling (i.e. 5s v 20s). To be sure, a 1359 fuller's tariff for Aire-sur-Lys (Artois) offered only a 25 percent cost-advantage in mill-fulling over foot-fulling per cloth; but the stipulated rate for the former may conceal a large economic rent for that particular mill-owner.

Such productivity gains do not mean, however, that manorial lords or town governments would necessarily have chosen to use relatively scarce and fixed water sites to construct fulling mills rather than grain mills, or would have borne the large extra costs in converting grain mills into fulling mills. Holt (1988) has recently demonstrated, with abundant evidence from thirteenth- and early fourteenth-century England,

that rentals, 'farms', and other returns were always much higher from grain mills than from fulling mills, often double or triple, especially in the more manorialised grain growing (mixed husbandry) regions of the Midlands and eastern England.

Nevertheless, fulling mills did become more widely diffused in later-medieval England (as elsewhere in western Europe) to displace foot-fulling in the greater part of the English cloth industry. Indeed, some years ago, in an engaging model designed to explain the structural economic changes of this era, Miskimin (1969) contended the Black Death and subsequent depopulations favoured such a diffusion, and in particular the conversion of grain mills into fulling mills, by their effects on relative prices and factor costs. Thus a radical alteration in the land:labour ratio inevitably produced a steady rise in real wages and a steep fall in grain prices (as supplies exceeded demand), land values, and rentals; and the consequent 'agrarian depression', particularly in discouraging demesne farming (with both free and servile labour), allowed the peasantry to gain greater personal freedom and economic powers, including more powers in resisting the once compulsory use of manorial grain mills.

Not surprisingly the economic facts of late-medieval England do not entirely fit or accord with this engagingly simple model. Not until the late 1370s or 1380s are there definite signs of a true agrarian recession, with such a wage-price scissors, and a contraction of demesne farming. Thereafter, the fall in grain prices was more often in accordance with monetary deflation than with any shift in relative prices (see below, pp.); indeed on several occasions between 1380 and 1500 'real' grain prices in fact rose, relative to livestock and industrial prices. Even though Holt has found evidence that some manorial grain mills were converted into leased fulling mills during the later fourteenth and fifteenth centuries, his data certainly do not indicate any widespread pattern of mill conversion. The diffusion of later-medieval fulling mills seems to be more a function of other, independent factors promoting the growth of the English cloth industry, especially in the southern and western regions, more pastoral than arable, less manorialised, with less congested populations, and with relatively more abundant and cheaper sources of water power. Possibly

rising industrial labour costs and declining land values along some river sites did encourage more clothiers to establish fulling mills. Even for urban draperies fulling-mills certainly came to be quite profitable from this era; for, as Keene (1985, 1990) has shown for Winchester, a new fulling-mill that the bishop had constructed at Prior's Barton, just outside the city (adjacent to a civic fulling mill dating from the 1220s), produced revenues that more than doubled, from £7 3s 0d in 1370-71 to £16 0s 0d in 1400-01; and in the following year the Winchester civic government built yet another fulling mill.

In other areas of late-medieval Europe, however, water-powered fulling experienced some retreat: especially in the Low Countries and Normandy. To be sure, Flanders and Brabant had never been very receptive to fulling-mills, much less so than Normandy and Artois, though contrary to widely accepted views water-mills had long been used throughout this region for many purposes, including mechanical fulling. But the reasons for this region's evident retreat from mechanical fulling during the later Middle Ages must await the analysis of structural and economic changes in the later medieval cloth industries of north-west Europe, in the following chapter (see below, pp. 000). Suffice it to say for now that the very same draperies in the late-medieval Low Countries that resisted the use of cards and spinning wheels were the same ones that eschewed fulling mills, for the same quality-oriented reasons.

Gig-mills and mechanical teaselling: the tentering and napping processes

The final technological innovation of any importance in the late-medieval woollen industry was the closely related gig-mill, which mechanised the napping processes (teaselling, raising, rowing). Because it also used centralised water-power, and because napping was customarily initiated by the fullers themselves, gig-mill machinery was generally added to an existing fulling mill. Again, the significance of this mechanical device can best be appreciated by first analysing the techniques of traditional tentering and napping: a labourious, painstaking part of cloth-finishing, and so crucial in determining the luxury quality of fine woollens.

Finishing really commenced when the fuller removed the wet cloth from his vat and transferred it

to be hung on the tentering frame, in order to dry the cloth, remove any of the wrinkles from fulling, make final repairs, and restore some of the dimensions lost from shrinkage (up to 50 percent). The frame consisted of a series of wooden poles, standing on a wooden platform, joined at the top by a fixed wooden cross-bar and fitted at the bottom with a moveable cross-bar. The cloth was placed lengthwise, by its selvages, on to hooks protruding from the upper and lower cross bars, a fixed pole at one end, and at the other, a moveable pole (templet, boem) rotated by a windlass. As the tenterer rotated the templet-pole, his assistants forced the lower cross-bar downward into slots on the vertical poles, thus stretching the cloth tautly in both directions, to ensure perfectly even dimensions throughout and a uniform surface area. While the cloth was on the frame, either the fuller or professional tenterers subjected it to a preliminary napping with teasels, to complete or perfect the felting and to raise any loose and protruding fibres, which were then clipped off by 'wet shearing'. Subsequently, after final repairs had been made, the dried cloth was delivered for final finishing (before dyeing) to the shearers, who began with yet another teaselling.

Though the shearers' dry-teaselling was far more vigorous and thorough than those of the fuller-tenterers, the technique was basically the same. About a dozen of these prickly teasels, the same *Dipsacus fullonum* discussed earlier, were fitted tightly inside a rectangular wooden frame with a long wooden handle, by which name the device itself was called ('handle'). For the initial raising of the cloth, slung over a high beam, hard teasels were employed, and then softer ones for subsequent raising. While the fuller, in raising the nap on the wet cloth on the tentering frame, generally *pulled* the handle over the surface area, the shearer (or teaseller) always *pushed* the handle from the bottom to the top of the dried cloth.

This tedious, arduous task, which could take up to eight hours or more for initial raising on a high quality woollen, could be reduced to a matter of minutes by the gig-mill, whose use is first documented in England in the early fifteenth century (before 1435). In essence, the water-powered mill rapidly rotated a metal cylinder, containing compacted teasels, across the face of the cloth, as that cloth moved along a revolving leather belt. According to a subsequent, seventeenth-century report, two men and a boy operating

a gig-mill could perform the tasks done manually by eighteen men and six boys (thus providing at least a 9:1 gain in productivity).

Chronologically the last textile innovation of the medieval era, it was also the least significant, chiefly because of its slow diffusion in the face of considerable resistance. Well before several parliamentary bans (1464, 1551), many English draperies had themselves opposed their use, and evidently again not on the grounds of technological employment (more a concern obviously of shearers than of drapers). Many believed or certainly feared that the gig-mill by its very rapidity and rigidity could inflict irreparable damage on these fine woollens, while the much slower and more plastic actions of the hand-teaseller, between repeated shearings, would enhance their quality. Nevertheless, despite the bans, its use can be documented throughout the sixteenth and following centuries, though possibly that use was confined to cheaper quality woollens.

Shearing and steel shears

Shearing, as just noted, is the final finishing process that alternated with napping; and although Leonardo da Vinci and others may have experimented with mechanized shearing in the fifteenth century, the traditional manual methods continued to be unchallenged throughout the European cloth industry until modern times. The traditional art of shearing was to clip or ‘crop’ the raised nap as close as possible in order to make the cloth surface completely uniform and smooth, and thus allow subsequently applied dyes to achieve their maximum brilliance; and such shearing also, obviously, completed the effects of fulling, felting, and raising in eliminating any visible weave patterns.

For this task the medieval and early modern shears were basically unchanged from Roman times: in the form of two razor-sharp steel blades, each about 45 cm long (18 in), attached to a U-shaped steel bow-spring, which also served as the shearer’s handle. The shearer placed a section of the cloth to be shorn onto a padded, downward-sloping table, with hooks along each side to hold the cloth in place. The shearer began by setting the lower blade, weighted with lead, firmly into the cloth’s surface at the top end of the slanted table. Opening and shutting the upper blade with his left hand, while using the other to position the shears,

he allowed the lower blade to slide by its own weight gently down the slope of the cloth, as he slowly and carefully cropped the nap; and so he proceeded until finally the whole cloth had been shorn. Usually the shearer subjected this cloth to several, repeated napping and shearings, and then a pressing in a wooden vise, before the cloth was finally ‘finished’. In the early-modern era, pressing was improved by ‘calendering’, with mechanically-powered rollers; but that technique lies beyond the temporal scope of this study.

Dyeing: wools, yarns, and cloths

For many cloths, the final manufacturing process was dyeing, though dyeing in fact could take place at any one of three stages of production: in the wool; in the yarn; and in the piece, usually (though not always) after shearing. As noted above, some cloths were woven from a variety of differently dyed yarns to become ‘medley’, ‘striped’ or ‘rayed’ cloths that were generally not re-dyed. But many more and perhaps a majority of later-medieval woollens were woven from wools that were first dyed blue with woad (*Isatis tinctoria*), and then redyed in the piece with some combination of other dyes (e.g. madder and/or brasilwood for reds; and weld, i.e. *Reseda luteolea*, or saffron, for yellows), often with more woad, to create a wide variety of colours: e.g., sanguine, brown, purple, ‘murrey’ or mulberry (purple-red), perse (bluish-grey), grey, and black. Although some wools were dyed in red-based colours (rarely yellow) to produce the striped and medley cloths, at this stage woad or indigo-blue was certainly preferred because, as a ‘substantive’ dye, its adherence to the wool fibres did not require a mordant, whose crystalline residues made the wools less supple and more difficult to work.

Indeed, woad was the most frequently used dyestuff in the late-medieval cloth industries; and such a high proportion of medieval woollens were woven from woad-dyed wools that cloth workers were frequently known as ‘blue nails’. The two major sources of the woad plant, though cultivated in many regions of medieval Europe, were Picardy and Languedoc; but from the mid-sixteenth century, increasing quantities of the dyestuff were extracted, in purer form, from the imported Oriental indigo plant (*Indigo tinctoria*). Woad-dyeing commenced with the production of *eau-sure*, by boiling a mixture of water, grated

madder, and bran in copper containers. After the bran impurities had precipitated, during the subsequent cooling, the solution was decanted and poured into stoneware vats. The dyers then added a mash of raw woad and potash (potassium hydroxide or potassium carbonate), and sealed the vat with an airtight lid to prevent oxidation and promote fermentation, which took about three days. Potash, derived from Baltic-based wood ashes, was not a mordant, as often claimed, but rather a chemical catalyst that made the woad water-soluble, thus permitting the required fermentation by hydrolysis, utilizing the components of the *eau-sure*, i.e. the amylaceous (starchy) compounds from the bran and the ruberythric acid, a glucoside in madder. The result was a leuco-derivative, colourless and quite soluble, when mixed with the warm water in a separate vat. The dyer then plunged water-moistened wools, yarns, or cloth into this vat containing the leuco-derivative, which immediately adhered to the wool fibres, as they were stirred with wooden forks (to promote dye-absorption). The wools, yarns, or cloths were then passed through ringers and hung on racks to dry, permitting oxidation, which then produced the desired and quite fast blue colour.

An entirely different group of dyers conducted the other form of dyeing, with ‘adjective’ red or yellow dyes, which, as noted, did require a mordant. By far the most common mordant was alum (potassium aluminum sulfate, or ammonium aluminum sulfate), obtained almost exclusively from Phocaea in Asia Minor (a Genoese monopoly from 1275), until the 1460s, when a new source was found in Italy, at Tolfa, in the Papal States. In this process, the dyers immersed the wools or cloth in a water-filled vat containing alum and also tartar. After this mixture had been boiled for several hours, allowing the alum to dissolve and adhere to the fibres, the dyer removed the wools or cloths, cleansed them, and restored them to the vat with new, alkaline water, which he boiled, while adding the madder (*Rubia tinctorum*). The red colorant so derived from the root of this widely cultivated European plant was actually the chemical *alizarin*, extracted from the madder by hydrolysis and fermentation (i.e. in the alkaline water); and the alum mordant (with tartar as a catalyst) permitted the *alizarin* to form a permanent chemical union with the wool fibres. Another though much less used red adjective dyestuff, imported and far more expensive, was *brazilwood* (Med. Latin

brasilium), extracted from tropical East Indian trees (genus *Caesalpinia*). From the 1530s, the Portuguese began supplying western European draperies with increasing quantities of a much cheaper source that came from their new South American colony of Brazil, obviously named after this Oriental dyewood.

Imperial ‘Purple’ dyes, Scarlet dyes and the medieval Scarlet

By far the most expensive dyestuffs to be found in the textile industries of the ancient Classical world, of the Byzantine Empire, and of western Europe (until the nineteenth century) were animal-based chemicals that produced the richly regal purple and scarlet colours. Of these two, the renowned Imperial Purple was by far the more expensive in the ancient and medieval worlds. Its various dyes, producing shades ranging from dark to bright, were extracted from the glandular mucus of three molluscs of the whelk family, found in the Mediterranean and adjacent Atlantic Ocean: *Murex brandaris*, *Murex trunculus*, and *Purpura haemastoma*. The famous Tyrian purple, known as *blatta* (βλᾶττα), was produced from a mixture of *Murex brandaris* and *Purpura haemastoma*. Their production under Imperial Rome was a jealously guarded secret that evidently did not survive the Empire in the West, but did continue as a monopoly under the successor Byzantine Empire, well into the medieval era, especially for the production of the most luxurious silk fabrics.

Medieval western Europe’s counterpart as the most aristocratic textile was the woollen ‘scarlet’, rivalling if not exceeding the finer Oriental and Italian silks in such fine qualities and price. Although one might naturally assume that this textile’s name was borrowed from the colour or dyestuff, the historical evidence indicates the very opposite: that in all West European languages the words for ‘scarlet’ developed first as a noun for the textile itself and only later came to be applied as an adjective to describe the colour. Furthermore, even though many woollen scarlets did indeed have that rich red colour, perhaps most by the very end of the Middle Ages, many had instead been dyed in a wide variety of other colours -- and some were even considered to be ‘white’.

The etymology of this word, both for the red dyestuff and the textile, still remains obscure; and the origins and very nature of this textile provide one of the most fascinating mysteries in the history of European

textiles. Many or most textile historians today still favour a thesis first propounded by Henri Pirenne and elaborated by his colleague J.-B. Weckerlin in a 1905 monograph. Noting that the Flemish towns, as the leading medieval producers of this aristocratic textile, called it *scaerlaken* (*scharlaken* in modern Dutch; *Scharlach* in modern German), Weckerlin contended that this Low Germanic word could have meant only a shorn cloth, from its two components: *schaeren* or *scheren*, to shear; and *laken*, a cloth. Without bothering to explain why the francophone Flemish towns (Douai, Lille), equally important in thirteenth-century production of these luxury woollens, called it instead *escalate* or *escallate*, closely cognate to Spanish and Portuguese *escarlat*, Italian *scarlatto* and English *scarlet*, none of which has any relation to ‘shearing’, Pirenne and Weckerlin nevertheless contended that the medieval ‘scarlet’ owed not only its name but its essential luxury qualities and exceptionally elevated prices to the very high-cost skilled labour involved in the complex and intricate shearing processes. Such interpretation is not sustained, however, by the later-medieval evidence, which clearly shows that the average cost of shearing scarlets was only 1.5 to 2.5 percent of the wholesale price, and furthermore that scarlets did not typically undergo any more extensive ‘re-shearing’ than did other fine woollens.

Yet recent philological research (Hildebrandt 1974) has revealed a text, one quite unknown to both Pirenne and Weckerlin, that does lend some seeming credence to their hypothesis: the earliest known documented form of this term, as an Old High German gloss on Latin texts in *De diversitate vestimentorum*, of the *Summarium Heinrici*, composed at Worms between AD 1007 and 1032. There it appears as ‘*scarlachen*’, to interpret a corrupt Latin text from Isidore of Seville’s famed *Etymologiarum* (c.560-636): ‘*Ralla* vel rullo que vulgo rasilis dicitur’. Since its root *radere* means ‘scraped, smoothed, shaved’, it could thus also mean ‘shorn’; and *ralla* appears as a term for ‘shaving-cloth’ in an English text of the 1440s. So, even if the Pirenne-Weckerlin theory fails to explain the true nature of the later medieval scarlet, this first appearance of the term may instead support the earlier discussed hypotheses about the introduction of the horizontal loom and the evolution of the true woollen as a heavily fulled and thus shorn luxury textile (see

above pp.).

The far older theory to explain the etymology and origins of the medieval scarlet, and one that remains more popular amongst philologists and linguists, was advanced by Du Cange (Charles du Frèsne, 1610-88), whose *Glossarium* stated that the European words for scarlet came from ‘the Arabic Yxquerlat’. That word is in fact Persian: *saḵirlāt* or its more common variant *saḵalāt*. Both Persian words were adopted relatively late (after c.1280); and the formation of the word *saḵirlāt* was evidently influenced by some variant of the Latinized forms of scarlet, which first appear, c.1050-1100, as *scarlata*, *pannos scarlitinos*, undoubtedly via the Italian *scarlatto*. These Persian words, however, owe their real origin to the Arabic word *siḵlāt*, more commonly *siḵlātūn* (سقلاتون), dating from at least the ninth century; and that term may be derived from the late-Roman Latin *sigallatus*, via the Byzantine Greek *sigallaton*, meaning a textile, linen or woollen principally, decorated in rings. But *siḵlātūn* is an unpromising linguistic ancestor of ‘scarlet’; for, though indeed a most luxurious textile, it was in fact a form of silk. Nevertheless, *siḵlātūn* had an evident linguistic influence on the *sc* and *lat* construction in all Latinized forms of scarlet previously noted.

That connection may lie in the fact that many or most of the silken *siḵlāt* - *siḵlātūn* produced in Muslim Spain (Andalusia), so close to western Europe, were dyed in *kermes* (a word derived from the Arabic *ḵirmiz* = worm): a rich, brilliant red dye extracted from the desiccated eggs of a species of pregnant shield-lice: *Kermes (Kermococcus) vermilio*, which infested various Mediterranean oaks. Two other, but far less frequently used varieties of this dyestuff were the Near Eastern, chiefly Caucasian, *Porphyrphora hameli* and the East European *Coccus polonicus*; but it must be noted that the insect *Coccus ilicis*, so often cited as the chief source of kermes, does not in fact produce this dyestuff. The true insect forms for scarlet dyes were known in the Classical world as *coccum* (ΚΟΚΚΟΣ) or *coccina*, meaning a berry; and, from its dried granular appearance, the medieval Christian world more logically called this exquisite dyestuff *granum* or *grain* (*grein*).

Thus, the European words for scarlet have two fundamental etymological roots. For the Latin-based

languages, the stronger influence came from the Arabic *siḳlāt*, meaning a luxurious textile with the brilliant, rich orange-red colour that came from this kermes dyestuff. The possibly older and predominant root, especially in Germanic languages, was the Old High German *scharlachen*, whose original meaning, as a fine luxurious woollen, heavily fulled and shorn, became transformed into the more specific meaning as the very finest and most costly of all such woollens, i.e. those similarly dyed 'in grain'. Indisputably, as so many texts from various medieval European draperies clearly demonstrate, all woollens called scarlets (or *scaerlaken*) were those that had been or were about to be dyed 'in grain', wholly or partially, with some variety of kermes, whose predominant sources were Andalusia, Valencia, Provence, and the Caucasus (Georgia and Armenia).

The equally well documented description of medieval scarlets in many colours other than pure scarlet-red does not, however, pose any real paradox or contradiction. For, completely in accordance with the dyeing methods described above, many scarlets were woven from wools that had been first dyed blue with woad, and then redyed 'in the piece' with kermes and other dyes to produce that wide variety of previously discussed colours: black, purple, murrey, brown, perse, sanguines, and even greys and greens. The term 'white scarlet' was related to the almost universal tripartite description of woollens according to the state of their yarns on the loom: 'blue' yarns, dyed in woad; 'medley' yarns, composed of variously dyed wools (for *mellés* or *gemengd laken*), or different coloured yarns woven to produce 'striped' cloths (*rayés*); and 'white', i.e. undyed yarns, for those cloths subsequently dyed only 'in the piece'. 'White scarlets' were woollens woven from undyed wools and dyed in the piece uniquely with kermes, in 'full grain'. English textile terminology came to reserve the term scarlet for just these 'full-grained' woollens. Certainly those scarlets fully dyed in kermes were by far the most expensive; and full-grained scarlets retained their primacy in the hierarchy of woollens even after the substitution of cheaper 'scarlet' dyestuffs, from the Spanish conquest of the Americas in the sixteenth century, principally Mexican *cochineal* dyes.

Costs, prices and values: how expensive were medieval scarlets and other luxury woollens?

The most effective way of demonstrating the extraordinarily high prices of late-medieval scarlets is

to estimate how many days income a highly skilled craftsmen would have had to expend in order to buy one, during the so-called 'Golden Age of the Labourer', in the mid fifteenth century, when real wages had reached their medieval peak. In Bruges, a master mason or carpenter, by far the best paid craftsmen in northern Europe, then earned 12d *groot* Flemish per day; and the purchase of a full-sized, full-grained Ypres *scaerlaken*, priced at £14 12s 0d *groot* Flemish (= £13 5s 0d sterling), would have a cost him 292 days wages, representing his employment income for about 17 months (1.39 years, at about 210 workdays per year); the much less well paid master masons in Antwerp, then earning 8d *groot*, would have needed 438 days wages (2.09 years' income) for this purchase. From such a *scaerlaken* (measuring 21.0m by 1.75m), three full dress suits could be cut, each of which would have cost the Bruges mason 97 days wages and the Antwerp mason 146 days wages. Similarly, in England, the cheapest full-grained scarlet in the wardrobe of Henry VI, priced at £13 10s 0d sterling (for a somewhat larger cloth, measuring 30 yds by 1.75 yds, or 27.4m by 1.6m), would have cost a London mason, paid 8d sterling per day, 405 days wages (1.93 year's income); and a mason living in Canterbury, Exeter or Oxford, earning only 6d per day, would have required his full pay for over two and half years (540 days wages) to buy that same cloth. The most expensive scarlet in Henry VI's wardrobe, at £28 10s 0d sterling, would have cost the London mason at least 855 days wages; and the 7.5 linear yards (or 7 metres) to make up a full suit would have required a full year's wages (214 days).

The principal reason why these medieval scarlets were so extraordinarily expensive was the high cost of their two key ingredients: the very finest English wools (March or Cotswolds) and the kermes dyestuff itself. The late-medieval Flemish and Brabantine draperies provide very good statistical evidence on the costs of manufacturing, dyeing, and shearing fine woollen broadcloths. For the pre-finishing stages, these English wools normally accounted for 65 to 75 percent of the draper's costs, depending of course on the actual grade of wool used. For a fully dyed and shorn scarlet broadcloth, the dyestuff itself, quite apart from any labour expended in dyeing, accounted for a minimum of 30 percent and sometimes 50 percent or more of total production costs, depending upon both the current price and grade of kermes and the quantity used in each

broadcloth (20 to 36 lb. or 9.1 to 16.3 kg). Hence these two raw materials together often accounted for 85 percent or more of total production costs and thus of the wholesale price.

In other fine Flemish broadcloths (from Ghent, Bruges, Ypres), the far cheaper vegetable dyestuffs -- woad, madder, weld -- accounted for about 10 - 18 percent of total productions costs; but for such non-scarlet broadcloths, the sum of raw material costs still accounted for about 70 to 80 percent of the mean price for Ghent *dickedinnen* broadcloths in the 1440s (£7 17s 0d *groot* Flemish = £7 2s 0d sterling). The capital costs, more for working capital than for fixed capital, are difficult to calculate; but clearly the remaining costs in labour were no more than 15 to 25 percent of the total, the bulk of which went for large quantities of poorly paid manual labour in combing, carding, spinning, weaving, and fulling.

According to the very detailed account books of the Medici's woollen drapery in mid-sixteenth-century Florence, of the total 'value-added' manufacturing costs in producing an undyed, unfinished fine-quality woollen broadcloth, those for wool-preparation, combing, and carding together accounted for 19.8 percent; spinning, for 47.1 percent; weaving, for 28.0 percent; and water-powered fulling (plus tentering), for 5.1 percent. The Medici drapery then used the far cheaper Spanish merino wools, which accounted for 30.0 percent of the fully finished woollens's final value; dyeing accounted for 11.6 percent; shearing and finishing, just 1.0 percent; oils and soaps, 2.8 percent; overhead and capital costs, 9.7 percent; and pre-finishing manufacturing labour costs, the remaining 44.9 percent. Somewhat similar though much less detailed production Italian costs can be found in the Datini account books for its Prato drapery in 1396-99 (Melis 1962): the average cost of the Majorcan, Minorcan, Provençal, San Matteo (Spanish), North African, and English wools accounted for 38.0 percent of fully finished cloth's wholesale value; wool preparation accounted for 25.5 percent; spinning, for 21.3 percent; weaving, for 12.9 percent; dyeing, for 15.5 percent, 'finishing' -- which evidently includes fulling, tentering, teaselling and shearing, for 15.8 percent; and 'other' costs, for 9.0 percent.

What we learn from these textile data on costs and prices is of fundamental importance in

understanding the history and economics of the later-medieval woollens industry. First, industrial labour, with a low productivity, was relatively very cheap, while raw materials, certainly for the higher-grade woollens, were very expensive. Thus, as was suggested earlier, the major profits lay in exploiting the trades in wools, dyestuffs, and finished woollens; and very little profit was derived from controlling the highly labour-intensive processes of cloth production itself. Secondly, if these raw materials were the chief determinants of cost and price, they were also the major determinants of luxury quality. In medieval Europe, almost all of the variations in both luxury quality and of the prices in wool-based textiles were determined primarily by the specific quality and quantity of wools and dyestuffs they contained, and only secondarily by the labour and technology employed. As already noted, the technological advances in spinning, fulling, and napping were widely eschewed in the luxury sector of the later-medieval woollens industry precisely because they were deemed to be so injurious to luxury quality, in an era when quality often ranked above price in highly competitive markets. Thirdly, the market for the finer quality luxury woollens was a very restricted and relatively inelastic one, limited chiefly to the upper strata of medieval European society, both secular and ecclesiastical; and even the very wealthiest aristocrats and cardinals were only infrequent consumers of these scarlets.

IV. THE ORGANIZATION OF MEDIEVAL CLOTH PRODUCTION:

An historical study of any industry depends, of course, not just upon its technological foundations and innovations, but even more on the nature of its organizational structure, which interlinked these technical processes together into a coherent and productive whole. No survey of western Europe's cloth-manufacturing, here confined to the years c.1100 to 1500, can do proper justice to its complex regional diversities over these four centuries.

Previously, during the early Middle Ages (fifth to tenth centuries), very few if any European regions

had engaged in market-oriented textile production – except possibly the coastal Low Countries, if they were indeed the manufacturers of the renowned but ill-documented ‘Frisian cloths’ of Carolingian times. In a basically agricultural economy, with few towns, for which international trade was intermittent and marginal, most textile-making had undoubtedly been rural and domestic, in the form of family-based crafts. Almost no formal division of labour was to be found, except in the workshops of religious orders and aristocratic estates, the latter called *gynoecia*. As that term indicates, almost everywhere the actual cloth manufacturing processes -- wool preparation, combing, spinning, and weaving -- were then performed chiefly, perhaps exclusively, by women. During the ensuing era, from the eleventh to early fourteenth centuries, the lives of cloth-workers in most major producing centres came to be affected, in varying degrees, by a closely related series of five major economic and social changes, some of which evolved most fully during the late Middle Ages. Each will be considered in turn, though not in a strict chronological order.

Mercantile capitalism, industrial specialisation, and the ‘putting-out’ system

The circumstances that led to the ‘Birth of Europe’ in the later tenth and early eleventh centuries (Lopez 1962) also produced the foundations for a veritable ‘Commercial Revolution’, as a remarkable revival and expansion in long-distance trade, both maritime and overland. Amongst the most important factors were the restoration of relative security, with the defeat or withdrawal of the final set of marauding invaders (Vikings, Muslims, Magyars) and the establishment of more powerful feudal kingdoms and principalities (England, France, Flanders); a strong, continuous demographic recovery that lasted for three centuries; the diffusion of several agricultural innovations, leading to rising productivity; and their fruits in an extensive urbanization that greatly enlarged old towns and created hundreds of new ones. In response to this economic growth and especially to expanding urban markets, several regions in western Europe began producing more and more textiles for export, certainly by the eleventh century.

Initially the most important and long the most prominent for its textiles was northwestern France, especially the counties of Flanders and Artois (separated from Flanders in 1190-91), formerly a leading cloth-

producing region in the old Roman Empire. They were followed by neighbouring principalities in the imperial Low Countries (Brabant, Hainaut, the Meuse valley towns, but not Holland until much later), the coastal towns of eastern England, the Rhineland, Normandy, Languedoc, Tuscany, Lombardy, Catalonia, and Aragon. But these newly expanding industrial regions could no longer rely on prior modes of production, since no household could itself produce an entire woollen cloth at a price and a quality that would sell in highly competitive foreign markets. To achieve such goals of industrial efficiency and high quality, in order to capture foreign markets, these export industries necessarily had to create new organizations that coordinated a much larger group of much more highly trained and specialized workers, each of whom concentrated on performing a specific assigned task in the sequence just outlined, thus illustrating Adam Smith's famous dictum that 'the division of labour is limited [determined] by the extent of the market'.

In these eleventh and twelfth-century textile industries, the predominant or governing role was performed, undoubtedly from the outset, by merchants trading in wools, dyestuffs, and the finished textiles; and the more successful became in effect 'mercantile capitalists'. For indeed their very success depended upon an ability to amass large capitals (from commercial profits and by borrowing), invested in considerable stocks of industrial inputs and outputs (i.e. cloths), and sometimes also in warehouses, ships or other forms of transport, and industrial implements. They also required considerable amounts of working capital to finance their commerce in raw materials and finished textiles, in trading ventures that often took several months to complete; and those known as 'merchant drapers' also needed capital to finance the craftsmen who actually produced the cloths: to provide credit and current coin so that they could acquire the raw materials, pay their own workers, and operate their drapery establishments (i.e. pay for rent, taxes, supplies, bookkeeping costs, other wages).

Undoubtedly the most famous merchant-draper 'capitalist' to be found in medieval western Europe is Jean Boinebroke of Douai (d. 1286), who flourished at the very apogee of the Flemish cloth industry, and whose wealth, economic, and political powers may have been quite atypical. Yet, though modern historians

have often accused him of the ‘capitalist exploitation’ of his workers, he was no ‘industrial capitalist’, a term that is clearly an anachronism for this era. He was instead principally a wool merchant, dealing in English and domestic wools; and his role as a cloth merchant was only secondary. Furthermore, he was also a civic politician, having served nine terms as alderman (*échevin*) in the town government; and he owned land, with many properties in Douai itself and a sheep farm outside. As a merchant, he provided wool on credit to industrial drapers, who pledged their cloths, looms, and sometimes even their homes as security; and some of them also rented their houses from him. But most of his wage-earning employees were those required for the wool trade itself: sorters, beaters, washers, and some wool-dyers (who worked in his dye-house). Although Boinebroke did employ a few others in cloth-making, chiefly to work some tentering frames that he owned, there is absolutely no evidence that he ever directly supervised the central processes of cloth production.

Instead, in many or perhaps most of the textile industries of later-medieval western Europe, the true industrial-entrepreneurs were typically weaver-drapers, who organized production by a domestic ‘putting-out’ (*Verlag*) system. They were usually subordinate to the merchants, purchasing wool and other raw materials from them on credit, receiving sufficient additional credit to finance their operations, and then selling the manufactured but unfinished textiles to the same or to other cloth merchants; and they thus enjoyed much less wealth and a lesser economic and social stature than these merchants. Typically, their enterprises were highly labour intensive with little invested fixed capital, principally their looms and home-workshops. Occasionally the draper might instead be a dyer, fuller-tenterer, shearer, or a cloth-broker (*upzetter*); but most were indeed master-weavers in origin. He (very rarely she) operated under various names: *drapier*, in France and the Low Countries; *lanaiuoli* in Italy; and *clothier* in England.

After commencing his role by purchasing the required wools, perhaps with a small cash ‘down-payment’, the draper delivered them to his chiefly female employees, who generally worked in his own shop or house, to ‘prepare’ them, i.e. to sort, beat, wash, and grease them. He might then also employ or

commission dyers to give some of these wools a preparatory foundation dye, chiefly in woad-blue, as noted above (unless these wools had been purchased from wool-brokers already prepared and dyed). Then, in order to have these prepared wools worked up into yarn for weaving, the draper had them 'put out' to a succession of chiefly though not exclusively female employees, who also worked for piece-work wages, but generally in their own homes, within the town itself, or in the adjacent countryside, with their own tools: i.e. the combers and carders (some of them male); and the 'rock'- and wheel-spinners. Hence the terms 'putting-out' and 'domestic' systems. In Florence, the *lanaiuoli* often sub-contracted this 'putting out' to *stamaiuoli* (yarn dealers). Once the warp and weft yarns had been separately spun, they were delivered to the draper, to be 'put out' in a similar fashion, respectively, to his warpers and weft-winders, who were also chiefly female, piece-work earners; but they worked either in the draper's own workshops or those of subordinate weavers, masters and/or journeymen, who were similarly employed for piece-work wages.

The final group of purely industrial artisans employed by the drapers were the master fullers, who worked in their own establishments, requiring some capital investment. For water-powered fulling mills (England, Tuscany), the capital investments were so large indeed that the owners were more often cloth-merchants, dye-merchants or dyers, drapers, or seigneurial landlords. Traditional foot-fulling, as previously noted, usually required the labour of two journeymen, supervised by the master. Each received from the draper a combination piece-work and daily-wage: so much per broadcloth fulled within three to five days, as specified. The journeymen actually received the higher rate per cloth; but the masters, who were engaged only part time in this arduous task, earned considerably more in aggregate by operating as many as four vats (i.e. employing eight journeymen). A Flemish fuller (c.1400), as noted earlier, processed about thirty to thirty-five broadcloths a year, while the average weaver produced only twenty broadcloths or less annually. Thus the Flemish cloth industry employed fewer fullers than weavers, typically in a ratio of about 6:10.

The master weaver-drapers, probably a minority of the community's weavers, were the one group of textile artisans who earned not wages or fees but profits: i.e., the difference or residual between their total

production costs -- chiefly in buying wool and in paying wages -- and their revenues, from selling the fulled cloths to various finishers, merchant-drapers, or other merchants, domestic and foreign. As one might suppose from the figures just cited, most weaver-drapers had small establishments, with very small profit margins, and thus enjoyed at best modest incomes. The very few who did become rich did so not so much by investing in many looms but rather by becoming merchants themselves; and by engaging in the wool, cloth, finishing, or dyestuffs trades, despite frequent urban legislation forbidding such practices. Indeed, much evidence from the late-medieval Low Countries indicates that many master-weavers (especially as drapers) and fullers were often engaged simultaneously in several occupations (commercial, industrial, and/or agricultural), e.g. as brewers, bakers, grocers, masons, and carpenters.

Apart from those drapers who became primarily merchants, the textile artisans who generally, if not always, enjoyed the highest incomes and social status, certainly in later-medieval north-west Europe, were those engaged in the finishing crafts, principally because their role was really more commercial than purely industrial. Fully professional artisans, earning stipulated fees rather than piece-work wages, the dyers and shearers worked for a variety of clients, chiefly merchants, who were more cognizant than ordinary drapers of shifts in consumer fashion, of changing demands for style, cut, and colour of cloths. Since they themselves had to purchase raw materials and tools and hire assistants, their income must also be considered as a form of profit, though evidently with a much larger profit margin than that enjoyed by most weaver-drapers. In the early to mid-fourteenth-century Florence, however, the dyers if not the finishers lost their professional independence to become little more than employees of the *lanaiuoli*, whose guild, the Arte della Lana, itself set the dyeing fees, with government approval.

A gender change: from female to male weavers

A concomitant change in the textile and especially the woollen cloth industry was a remarkable gender change: a transformation of weaving to become an almost exclusively male occupation. Possibly it was related to the introduction of the new horizontal loom, or its subsequent variants. Influenced by Rashi's

description of the new loom as one ‘by which *men* weave with their feet’, and in particular by physical descriptions of the later broadloom, some historians have assumed that men -- large and strong men -- were more suited to its very arduous physical requirements, in working the treadles, ‘throwing’ the weft-bearing shuttle between them, and beating the weft up into the fell of the cloth. But the gender change may be equally or more related to the organizational changes just discussed, which made the weaver the key industrial entrepreneur. At the same time, those changes also led to the formation of professional craft guilds to protect and promote the economic, social, and political interests of these weaver-drapers and other male artisans who shared in dominating the processes of textile production.

As Howell (1986) has cogently argued, most-high status industrial crafts became male-dominated in the highly patriarchal society of later medieval Europe. While women were tied to child-rearing and domestic duties, men had far greater freedom to engage in the economic, social, political, and indeed military activities connected with guilds and town governments deemed essential to protect their crafts, activities that necessarily took place outside the home and family. But low-status occupations -- such as wool-beating, combing, carding, spinning, warping and weft-winding -- had no such requirements, and thus they fitted in well with and were interspersed with domestic household activities, to remain largely female occupations. To be sure female weavers, dyers, and finishers (if not fullers) are to be found in the later-medieval industry, on rare occasions, but chiefly as widows who carried on their late husband’s occupations. The nature of these industrial and gender relationships (i.e. male patriarchies) can best be explored by examining the next set of transformations involving many, if by no means all, the cloth industries of later medieval western Europe: not only the development of craft guilds, but more particularly the economic and social strife involving those guilds.

Guilds and guild strife in north-western Europe: England, the Low Countries, Cologne

The organization of genuine and independent craft guilds in the textiles industry was relatively late, in most regions of medieval Europe, developing only after varying periods of urban dominance by merchant

guilds. England seems to be a surprising exception, for the Exchequer rolls of 1130-31 record payments (royal taxes) by weavers' and other cloth guilds from London, Winchester, Lincoln, Oxford, Nottingham, and Huntingdon. In England, as indeed elsewhere in most towns of northern Europe, only four groups of male cloth artisans were successful in forming guilds: the weavers, the fullers, the dyers, and the shearers (but see pp. 000 for Italy). Carus-Wilson (1952, 1987) has speculated that, since fullers and dyers both required exclusive use of waterways for their crafts, they may have been the first textile artisans to form guilds in order to claim and protect these property rights; but she and other historians have also suggested that religious and social (or welfare) functions may have been just as important as economic factors in the origins of west European textile guilds.

Nowhere in late-medieval Europe did craft guilds leave a greater mark upon the history of textiles, for good or ill, than in the Low Countries, juridically part of the Germanic 'Holy Roman Empire', except for Flanders west of the Scheldt, a French royal fief. Though their textile guilds achieved a formal, legal status later than their French and English counterparts, after many violent struggles, they ultimately gained, especially in Flanders, much more economic and political power. Throughout the Low Countries, the chief grievance of the textile artisans was the way in which so many ruling mercantile oligarchies ('urban patriciates') had used the machinery of urban governments to set arbitrary wages, to prevent craftsmen from assembling, bearing arms, or engaging in political activities, and thus to deny them any voice in the town governments. Many though not all of these 'patricians' based their power in urban governments upon membership in two mercantile guild associations or confederacies, embracing many towns in the Low Countries: the Flemish Hanse of London, dominating the wool-import trade (up to the 1270s), and the Hanse of the Seventeen Towns, dominating cloth sales at the Champagne Fairs (to the 1290s).

During the thirteenth century, the textile artisans' sense of grievance was greatly exacerbated by the combination of rapid population growth and periodic inflations, producing a strong secular upswing in consumer prices that generally outstripped any rise in money wages. One of the first recorded urban

rebellions, involving the *povre gent, telier* [weavers] *et foulon*, and a massacre of ‘patricians’, took place at Valenciennes (Hainaut) in 1225. More rebellions followed in the 1240s: in 1245, the famous *takehans* -- literally ‘take hands’, a veritable industrial strike -- in Douai (francophone Flanders), and in 1248 an abortive strike by the fullers of Leeuw (in Brabant). Thirty years later, in 1274, at the end of an Anglo-Flemish trade dispute that had seriously impeded wool supplies, the weavers and fullers of Ghent agitated against the urban patriciate. Despite the flight of their leaders into Brabant, they gained support from Countess Marguerite (1244-78) and her son Guy (1278-1305), who tried to replace this urban oligarchy (known as the XXXIX) with an annual magistracy; but the countess was thwarted by the oligarchy’s largely successful appeal to France’s high court, the Parlement de Paris, by which the patriciates also acquired the hostile epithet of *Leliaerts* – the men of the French royal *fleur de lis*.

By far the worst social disturbances occurred shortly after, in 1280-81: at Tournai (a French bishopric and major cloth producer), Saint-Omer (Artois), Damme, Ypres, and Bruges. Though the Bruges *Moerlemaye* was chiefly a conflict between parties within the ruling mercantile élites, the more savage ‘Cokerulle Uprising’ at Ypres was more purely industrial, in reaction against both the wage scales imposed on fullers and shearers (who evidently did have some form of guild organization), and evidently also upon cloth workers from the neighbouring village of Poperinge, who quickly joined or precipitated the revolt. Suppressed just as quickly, with heavy fines imposed, the chief aftermath of these rebellions was to exacerbate the urban fiscal crises, thus increasing the tax burden on the commoners.

This social strife finally culminated in a veritable Flemish revolution during the Anglo-French wars of 1294-1303; and Flemish involvement in the war became inevitable when Edward I banned English wool exports. Philip IV of France, having already subjected Flanders to the supervision of his bailiff of Vermandois (1287), and now concerned that Count Guy might ally himself with Edward I to restore the wool supply, quickly intervened. He imposed royal ‘guardians’ on the Flemish towns, forbade all Flemish commerce with England, encouraged an invasion by the neighbouring count of Holland-Hainaut; finally, in

1296, he declared Flanders forfeit to the crown. The following year, a desperate Count Guy made an alliance with Edward I, and abolished the *Leliaerts* governments of Ghent and Douai, in favour of his own supporters, known as the *Clauwaerts* (after the count's 'lion's claw' emblem). Philip IV then invaded and quickly conquered half of Flanders, before arranging a truce with Edward I (1297). Upon its expiry, in May 1300, he seized the rest, and incorporated Flanders into the royal domain, while placing the county under both military occupation and the oppressive rule of the *Leliaerts*, with even heavier tax burdens to pay for war damages. Just a year later, the Flemish *Clauwaerts*, led by Bruges guildsmen and sons of the imprisoned count, revolted; and at the famous Battle of Kortrijk (Courtrai) in July 1302, their infantry army, chiefly guild militia, achieved a seemingly miraculous victory over the French cavalry, allowing them savagely to despoil the *Leliaerts*. Two years later, however, the Flemish lost two crucial battles, on land and sea, and were forced by the onerous treaty of Athis-sur-Orge in 1305 to yield the important francophone drapery towns of Douai and Lille, pay heavy indemnities, and recompense the *Leliaerts*.

Nevertheless, this and subsequent peace treaties (to 1320) did implicitly recognize the independence of Flemish-speaking Flanders; and the new urban constitutions finally gave the textile and other craft guilds legal recognition and collectively an influential voice in Flemish town governments, above all in the *drie steden* of Bruges, Ghent, and Ypres (which had admitted some guildsmen as early as 1294). Initially, however, the guildsmen aldermen (*échevins* or *schepenen*) were not considered to be formal representatives of their *ambachten* or guilds, a formal status evidently not recognized before the 1360s (certainly in Ghent). The *Leliaerts*, however, were by no means excluded from the post-1302 town governments, despite their even earlier decline in economic power, as foreign merchants -- chiefly Italian and German -- gained increasing control over both the wool-import and cloth-export trades. Indeed as a newly reconstituted *poorterie*, with many nouveaux riches landholding adherents, they were frequently successful in allying with various guild factions, especially the collective of 'small guilds', to reassert their power in the town governments. The textile guildsmen, even if and when they collectively commanded a majority, rarely ever

succeeded in dominating town governments for long, because their leading members, chiefly weavers and fullers, were so often in conflict, the former striving for supremacy, the latter for survival. The textile (and other craft) guilds themselves were dominated by the masters, though the journeymen (*knapen*), if not the apprentices, were usually given some say or vote in the selection of guild *jurés* (*geswornenen*) and other guild officers.

In the Flemish weavers' guilds those masters who were also industrial drapers exercised the real power; and the chief opposition to their power came from the fullers, who, as males, were the only subordinate wage-earning employees of the weaver-drapers with their own guild organization, similarly dominated by the masters. Unhappily for the Flemish cloth industry, its history during the fourteenth century was all too frequently marred by bitter, often violent strife between these two guilds, especially when the fiscally-straitened counts frequently engaged in radical coinage debasements that produced drastic inflations, which in turn provoked the fullers into striking for higher wages. As noted earlier, the fullers' wages usually accounted for about 20 percent of the weaver-drafter's value-added manufacturing costs; and the none too prosperous weaver-drapers, with such narrow profit margins, and facing ever declining cloth sales in this era quite naturally sought to thwart or repress these wage demands by gaining dominance in the urban governments (usually by expelling the fullers). To be sure, the very complex political conflicts that ravaged fourteenth-century Flanders -- and especially the three great rebellions of 1323-28, 1338-49, and 1379-85 -- involved far many more issues than just wages; but the wage issue did play a role in the latter two, and in several other strikes and conflicts as well in late-medieval Flanders: particularly, in 1355, 1359-61, 1364-7, 1372-73, 1390-92, 1422-3, and 1429-33.

In the neighbouring, large imperial duchy of Brabant, similar revolutionary movements involving industrial craftsmen had swept through the major towns (and also those of the bishopric of Liège) immediately after the Flemish victory at Kortrijk, in 1302. By 1306, however, the urban merchant-patrician oligarchies, with the aid of military forces led by Duke Jan II (1294-1312), had decisively crushed these

revolts and suppressed the guildsmen, who were forbidden to bear arms or assemble without permission. A strong, stable alliance between the mercantile-draper oligarchies and the dukes, in combination with a weak feudal overlord (the Holy Roman Emperor) who was far too distant to hear appeals from any communal opposition, thus explains relative social stability in the Brabantine cloth towns, and the firm rule of merchant drapers through their *Lakengulden*, for the next seventy years. Undoubtedly, the Brabantine draperies did benefit from such peace amidst the continued turmoils afflicting the Flemish draperies.

By the 1370s, however, the Brabantine draperies were also experiencing a severe decline, from depressed markets in plague-ridden, war-torn, depopulated Europe, thus undermining the powers of the mercantile oligarchies. Furthermore, they had already lost their native ducal ally. With the death of Jan III in 1356, without male heirs, the foreign Duke Wenceslas of Luxembourg became duke of Brabant and then, in 1378, Emperor as well. In that same year, the town government of Leuven, the weakest of the Brabantine drapery towns, agreed to a new constitution that organized the craft guilds into ten 'nations', each supplying a member for the council of *jurés* (*geswornenen*), and permitted guild leaders to stand for aldermanic office, sharing power with the mercantile 'patricians'. In 1421, Brussels received a similar town government with some similar participation by the textile guilds, whose industry, however, was now far too decayed to permit them much real power.

Elsewhere in northern Europe, apart from the English towns just discussed and several northern French towns, Cologne provided the only other prominent example of flourishing and politically powerful textile guilds. In 1396, the weaver-draper guild had been at the forefront of an urban revolt that established a new corporate government. Subsequently, this government permitted or established three new textile guilds, which, surprisingly, were exclusively female: the yarn makers, gold-thread spinners, and (from 1437) the silk makers. But, these female craftsmen lacked any real power, and were certainly not personally involved in any serious industrial strife, because they were so firmly dominated by other crafts-guildsmen and/or merchants, males who were so often the husbands of these textile artisans.

Italian cloth guilds: the case of Florence

In the Mediterranean south, by far the most important cloth-making city during the fourteenth century was Florence, in Tuscany, which also provided the closest counterpart to the Flemish industrial strife during this troublesome century. That strife was directed against the drapery guild known as the Arte della Lana, a leader of the seven-member Arti Maggiori that had long dominated the Florentine government; but the conflicts did not involve fullers, perhaps because the Florentine industry had largely displaced foot-fullers with fulling-mills (along the Arno). In 1324 and again in 1338 the Arte della Lana forbade any subordinate artisans (*sottoposti*) of the *lanaiuoli*, or their employees, to organize their own guilds on penalty of complete expulsion from the industry (*divieto*). But shortly after, in 1342, the foreign adventurer, Walter de Brienne, Duke of Athens, became military ruler of Florence; and, seeking popular support, he exploited grievances against the Arte della Lana by granting the cloth-dyers and soap-makers their own combined and independent guild, the Arti di Tintori e Saponai. Just a year later, in August 1343, Brienne was deposed, and the newly restored old regime abruptly abolished this upstart guild. That still did not deter a group of male wool-carders and combers from agitating for their own guild and higher pay: at least not until the government arrested and hanged their leader, Ciuto Brandini, in May 1345. The government just as ruthlessly crushed the next strike, by cloth-dyers during the famine of August 1368, when the Arte della Lana imposed its dreaded *divieto* on rebellious artisans.

Ten years later the Florentine cloth industry was shaken by the most famous revolutionary movement in late-medieval Italy: the Revolt of the Ciompi. Its origins lay in Florence's ruinous 'War of the Eight Saints' against the papacy, which aggravated an ongoing economic depression, especially severe for the cloth industry, that had produced widespread unemployment. In June 1378, after the pope had placed Florence under an interdict, violent strife erupted when pro-papal Guelphs attacked the pro-war Ghibellines, only to suffer a brusque defeat. But in mid-July, a revolutionary mob, composed chiefly of cloth artisans, the so-called Ciompi, overthrew the Ghibelline government, and replaced it with a new regime, temporarily led by

Michele di Lando, a wool-carder. By early August it had created not one but three new textile guilds, who were admitted to the communal government as part of the collective Arte del Popolo di Dio: the Arte dei Tintori (the dyers guild, which also included master carders and master fullers); the Arte dei Farsettai (shirt-makers guild, including master shearers); and the Arte dei Popolo Minuto (the Ciompi itself, by far the largest, with journeymen wool-beaters, combers, spinners, weavers and fullers). The Popolo Minuto leaders, angered by unresolved grievances, soon overplayed their hand by demanding even greater powers.

The exasperated government responded by crushing the Ciompi and abolishing the Arte dei Popolo Minuto. The other two guilds, which had wisely sided with the government, were temporarily spared, but only until 1382, when another communal crisis allowed the old regime of the seven Arti Maggiori, including the Arte della Lana, to regain full power in a re-organized government (representing twenty-one old guilds), which then abolished these remaining textile guilds. Thus ended the final challenge to the authority of the *lanaiuoli* and the cloth merchants, who, however, proved unable to prevent the Florentine cloth industry's now slow but irredeemable decline.

The 'spread of rural industries': A socio-economic transformation?

Since this discussion of guilds and guild strife has had a decidedly urban focus, an analysis of the 'spread' of rural clothmaking, as another socio-economic transformation that looms so large in studies of medieval textiles, might seem an appropriate way to end both this section and this chapter. Indeed, many economic historians have contended that the primary reason why the countryside of later-medieval Europe successfully attracted so many new industries was the relative freedom that it offered from guilds and other restrictive urban institutions.

But too often the standard portrayals of rural cloth-making present false historical dichotomies. From the earliest records of the major textile-producing regions, there was always some rural (village) cloth making; and though the relative extent of rural textile industries may have grown in the later Middle Ages, rural production by no means ever supplanted and displaced urban industries. Furthermore, in many regions,

much urban production had long depended upon part-time rural labour for many of the preliminary stages of cloth production, particularly combing, carding, and spinning. At the same time, other distinctions between urban and rural, town and countryside, became blurred. When village cloth production did flourish and become independent of the larger urban centres, such villages were often transformed into small towns, with their own corporate structures, and with few if any differences from so-called 'urban' production. Village or rural textiles undeniably achieved considerable importance in the medieval and especially later medieval eras; but their importance can be properly understood only within the context of the historical development -- growth, change, and decline -- of the major cloth industries of western Europe from c.1100 to c.1500, the subject of the companion study on *The West European Woollen Industries and their Struggles for International Markets, c.1000 - 1500*.